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Source Control Evaluation and Source Control Alternatives Evaluation Operable Unit 5 Swan Island Upland Facility Portland, Oregon

Prepared for:
Port of Portland

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1.0 Introduction

1.1 Purpose

This report presents an updated Source Control Evaluation (SCE) and Source Control Alternatives Evaluation (SCAE) for operable unit (OU) 5 (the Facility) of the Swan Island Upland Facility (SIUF) located at 5225 N Channel Avenue in Portland, Oregon. OU5 was originally part of OU2. In 2014, OU5, consisting primarily of the riverbank portion of OU2, was split from OU2 to form a separate operable unit. In 2010 and 2011, an SCE was prepared for OU2 and concluded that an SCAE was warranted to address potentially erodible soil on the riverbank (Ash Creek Associates [Ash Creek], 2010 and 2011). An SCAE was prepared for the OU2 riverbank (Ash Creek, 2012). In a letter dated November 4, 2014, the Oregon Department of Environmental Quality (DEQ) provided comments on the SCAE (including comments from the U.S. Environmental Protection Agency [EPA]). Also, since 2011, additional riverbank soil sampling has been completed. In response to the comments and additional sampling, this report presents a revised SCE and SCAE for the OU5 riverbank.

Figure 1 shows the location of the SIUF, and Figure 2 shows the boundaries of OU5. This source control work was prepared in response to a request by the DEQ to identify, evaluate, and control sources of contamination that may reach the Willamette River consistent with the DEQ-EPA Portland Harbor Joint Source Control Strategy (JSCS; DEQ, 2005).

1.2 Regulatory Framework

This work is being conducted under an agreement between the Port of Portland (Port) and DEQ – Voluntary Agreement for Remedial Investigation, Source Control Measures, and Feasibility Study – dated July 24, 2006. For the purposes of the work conducted under that agreement, the SIUF has been divided into five OUs designated as follows.

- OU1 – Approximately 57 acres of upland property owned by Shipyard Commerce Center LLC (formerly Cascade General), and operated as the Vigor Marine Ship Repair Yard and formerly known as the Portland Shipyard.
- OU2 – Approximately 19 acres of upland property owned by the Port south of N Channel Avenue, formerly referred to as the N Channel Avenue Fabrication site.
- OU3 – Approximately 2.5 acres of upland property owned by the Port on N Lagoon Avenue that includes the property at 5420 N Lagoon Avenue and the adjacent property to the north that provides access to Berths 308 and 309.

- OU4 – Approximately 7.8 acres of upland property between OU1 and OU2. Until 2008, OU4 was part of OU2, but was designated a separate OU to facilitate the sale of the property from the Port to Shipyard Commerce Center LLC.
- OU5 – Approximately 5 acres of property between OU2/OU4 and the Willamette River, consisting primarily of the upper portion of the riverbank.

Figure 2 shows the locations of the OUs. The riverside boundary of the OUs is the ordinary line of high water (OLHW) of the Willamette River.

1.3 Report Organization

A description of the Facility is presented in Section 2. Section 3 presents background on the investigations of riverbank soil and presents a weight-of-evidence evaluation of the potential for adverse effects on sediments. Specific objectives of the proposed source control and evaluation criteria used are presented in Section 4. Section 5 describes the areas targeted for source control. Section 6 evaluates potential source control measures and the recommended source control measure is presented in Section 7.

2.0 Site Background

2.1 Facility Description

Figure 2 shows the layout of OU5 at the SIUF. The property covers approximately 5 acres on the riverbank on the south side of Swan Island. The property consists of the riverbank adjacent to OU2 and the riverbank plus a narrow strip of upland adjacent to OU4. The length of the property fronting the Willamette River is 2,700 feet. The land surface elevations at the top of bank generally range between 33 and 38 feet (National American Vertical Datum, 1988 [NAVD88[).

A detailed description of the riverbank is presented in the SCE Addendum (Ash Creek, 2011). Between OU5 and the river (below the OLHW), the riverbank is covered with rock, concrete debris, rip-rap, and beach sand. Above the OLHW on OU5, willows, Himalayan blackberry, and weedy vegetation are well established. Much of the riverbank appears stable, but erosion features are present as described further in Section 3.4.2

The portion of OU5 between OU4 and the top of the riverbank is 2.7 acres of vacant land. The vacant property is level and covered with compacted gravel.

OU5 adjoins OU2 and OU4. OU2 is leased from the Port by two parties. Figure 3 is a Facility plan overlain on a 2011 aerial photograph showing the various use boundaries. Daimler Trucks North America LLC has the leasehold for approximately 7 acres at the southeast end of OU2. The leased property is used to temporarily stage trucks and trailers. Cemex has a leasehold on 12.1 acres at the western end of OU2 to operate a concrete batch plant. Operational features include the concrete mixing plant, truck scale, mixer truck parking area, aggregate storage piles, a storm water treatment swale, and a process water storage/settling pond. Process water and storm water from the batch plant are collected and used in the concrete manufacturing process. OU4 consists of a paved parking lot.

2.2 Upland Investigations

Since 2000, the Port has completed facility-wide OU-specific RI activities. These investigations and the corresponding data relevant to OU5 are summarized in the SCE (Ash Creek, 2010). Following the SCE, additional riverbank sampling was completed with the results summarized in the SCE Addendum (Ash Creek, 2011) and riverbank sampling letter (Apex, 2015). Data from these studies were used to update the SCE in Section 3.

3.0 Site Characterization

This section updates the chemical screening conducted in the original SCE to include additional data collected and to include the Portland Harbor preliminary remediation goals (PRGs) proposed by EPA in April 2014. The SCE (Ash Creek, 2010) and SCE Addendum (Ash Creek, 2011) evaluated the range of potential transport mechanisms and source materials and concluded the following.

- There are no over water activities at OU5.
- Utilities are located 8 to 25 feet above the water table, so utilities are not a preferential pathway for groundwater migration.
- There are no stormwater inlets on OU5.
- Groundwater is not a source concern based on:
  - Chemicals in groundwater and adjacent river sediments do not correlate;
  - Chemicals in subsurface soil are consistent with background;
  - Metals detected in groundwater nearest the river are consistent with background; and
  - Organic chemicals detected in groundwater were infrequently detected, have stable or downward trends, and have a low affinity for sediments.
- Based on the presence of metals, polycyclic aromatic hydrocarbons (PAHs), Tributyltin (TBT), and polychlorinated biphenyls (PCBs) above SLVs in riverbank soil, and the potential for erosion of the riverbank, riverbank soils are a source control concern.

Because it was concluded that only riverbank soil poses a potential source control concern, this update is for riverbank soil only.

The updated screening process consisted of the following steps.

- Summarize and compile applicable soil data;
- Compile SLVs;
- Screen data against lowest relevant SLVs to identify chemicals of potential concern (COPCs);
- Screen COPCs against relevant SLVs for applicable pathways and receptors to identify chemicals of concern (COCs);
- Evaluate potential for adverse effects on sediments; and
- Screen upland human health and ecological risks.

3.1 Riverbank Soil Data

3.1.1 Conceptual Source Model

An evaluation of the history of Swan Island and potential contaminant sources was conducted as part of the remedial investigation and SCE. A description of the site history is presented in the SCE (Ash Creek, 2010) and summarized as follows:

- 1923 to 1931 – Development of Swan Island;
- 1931 to 1941 – Portland Airport;
- 1942 to 1949 – Storage area/support services for military-era ship building and related industries; and
- 1950 to Present – Variety of light industrial uses.

From these activities, potential sources of riverbank contamination identified were historical fill, stormwater outfalls, historical transformers, and upland activities. The following paragraphs describe these potential sources. Notwithstanding these potential sources, there are no known ongoing sources of contamination to riverbank soil.

Historical Fill. Swan Island originated as a natural bar in the Willamette River. The portion of the island in the vicinity of OU5 was constructed in the 1920s from sand dredged from the Willamette River. A detailed review of aerial photographs conducted for the SCE Addendum (Ash Creek, 2011) confirmed that no substantive filling (i.e., fill changing the location of the top of bank) occurred on OU5 since the original island construction. Because the filling that created the current island was conducted prior to the origination of many industrial chemicals, especially PCBs, the fill placed during island construction is not expected to be a source of impacts to riverbank soil.

Stormwater Outfalls. A total of nine stormwater outfalls were identified along the OU5 riverbank. The outfalls are shown on Figure 3. Of these outfalls, six have been abandoned and one is inactive. Only two outfalls are active, WR-399 drains a paved parking lot (OU4) and WR-163 drains a small portion of OU2 (one catch basin) and the paved parking area for McCarthy Park. Composite soil samples were collected below seven of the nine outfalls (the two outfalls not sampled were located more than five feet below the OLHW). These data are discussed in more detail below in Section 3. In comparing the data collected below outfalls to data collected elsewhere on the riverbank, it is inconclusive if the discharges from outfalls were sources to riverbank soil.

Historical Transformers. A historical transformer platform was located on and extending over the OU5 riverbank. Soil samples collected from the former transformer pad location had concentrations of PCBs lower than typically detected elsewhere on the riverbank, indicating that the transformers are not likely substantive sources to riverbank soil.

Upland Activities. There is a history of industrial activities in the upland areas adjacent to OU5 beginning with development of the shipyard in 1942 through to the present. Impacts to upland soil at the east end of OU2 (adjacent to OU5) are documented – removal of approximately 3,500 cubic yards of surface soil containing arsenic was completed in early 2015. No specific activity has been identified as a source of impacts to the riverbank. Additionally, no riverbank filling activities, even in limited quantities, have been identified after the original construction of the island. However, the presence of concrete and other debris scattered on the riverbank is an indicator that historical activities may have directly affected the riverbank.

3.1.2 Soil Sampling and Data

Riverbank soil sampling was conducted between 2006 and 2014. The sampling events and data are discussed in the SCE (Ash Creek, 2010), SCE Addendum (Ash Creek, 2011), and riverbank sampling letter (Apex, 2015). Figure 3 shows the riverbank soil sample locations.

In general, soil sampling was conducted using judgmental sampling approaches, targeting those areas either most likely to have impacts (stormwater outfalls and a former substation) or those areas with observed erosion impacts. Judgmental sampling that targets likely impacted areas results in data that is expected to be biased toward higher concentrations.

Additionally, three different sampling methodologies were used: discrete, composite, and incremental sampling methodology (ISM). Discrete samples were collected from areas with observed erosional impacts. Also, in some cases, discrete sub-samples collected for composite or ISM samples were analyzed.

Composite samples were collected at potential impacted areas: three-point composite samples were collected at stormwater outfall locations and four-point composites were collected at the former substation location. One ISM sample was collected from the riverbank below where a soil remedial action was completed on the adjacent upland portion of OU2.

Riverbank samples were analyzed for one or more of metals, PCBs, PAHs, and TBT. These contaminants of interest (COI) were selected based on the results of the SIUF remedial investigation.

Tables 1 through 11 present a compilation of the OU5 riverbank data.

3.2 Compile SLVs

For the riverbank soil erosion scenario, soil could be transported to river sediments where receptors are directly or indirectly exposed to the sediments. The following screening levels were used to assess human exposure to sediments.

- JSCS SLVs for soil/stormwater sediment; and
- Lowest relevant EPA Portland Harbor draft sediment preliminary remediation goals (PRGs)[1].

JSCS SLVs were selected by DEQ and EPA using a range of established human and ecological screening criteria. The SLVs do not account for background conditions (anthropogenic or naturally occurring) in the Portland Harbor Superfund Site; therefore, in some cases JSCS SLVs do not represent standards that are realistically attainable. For example, the JSCS SLV for total PCBs in sediment is 0.39 µg/kg, while the background concentrations currently under consideration by EPA range between 6 and 17 µg/kg.

The screening level values used are listed in Tables 1 through 11.

3.3 Identify COPCs

In Tables 1 through 11, the riverbank soil data are screened against the SLVs. For COPC screening purposes, it was assumed that the soil would be transported without a change in concentration of the COI. This assumption is likely conservative[2] and adds uncertainty to the evaluation. Each COI detected at least once above an SLV was retained as a COPC for OU5. The COPCs thus identified include the following:

- Metals – arsenic, cadmium, copper, lead, and zinc;

[1] Draft final PRGs issued April 11, 2014.

[2] COCs are generally associated with the finer soil fractions that are more likely to be widely dispersed during transport processes, reducing the overall concentration of COCs after transport to sediments.

- PAHs – anthracene, benzo(g,h,i)perylene, indeno(1,2,3-cd)pyrene, carcinogenic PAHs (cPAHs) as benzo(a)pyrene equivalent (BaP Eq), and low-molecular weight PAHs (LPAHs);
- PCBs –Aroclor 1260 and total PCBs; and
- Organotins – TBT.

3.4 Identify COCs and Evaluate Potential for Adverse Effects on Sediments

In accordance with the JSCS guidance, the following evaluation considers multiple lines of evidence to be considered independently and collectively to identify the potential for adverse effects on sediments from riverbank soil. These include the following:

- Factors related to chemical properties and concentrations
  - Contaminant concentrations
    - Magnitude of exceedance above SLV
    - Magnitude of exceedance above PRG
  - Regional background soil concentrations of metals
  - Presence of persistent bioaccumulative chemicals
  - In-water sediment data in proximity to source area
- Factors related to physical properties of riverbank
  - Site surface conditions (e.g., exposed soil, paved, slope)
  - Riverbank stability (e.g., potential for erosion under extreme rainfall events, potential for erosion under flood conditions, bank erosion rates)
  - Soil properties (e.g., soil type, compaction, erodibility, permeability)
  - Evaluation of potential soil erosion and contaminant transport (e.g., modeling, quantitative erosion calculations)
- Extent of impacted soil and proximity to the river
- Estimate of potential contaminant loading to the river

3.4.1 Identify COCs

Using the JSCS factors related to the chemical properties and concentrations listed above, this section evaluates each of the COPCs to identify COCs in riverbank soil. For the COC screening, it is recognized that if riverbank soil is eroded into the river sediments, the concentrations of COPCs will not remain constant. As noted in Section 3.3, the process of eroding and transporting soil to the river will disperse the soil fraction carrying the COPCs over a wider area in the sediments than in the riverbank, reducing overall concentrations. Therefore, riverbank soil concentrations that only slightly exceed screening levels are generally not considered to be at levels of concern. Other factors such as frequency of detection, background concentrations, and adjacent sediment data are also considered on a qualitative or semi-quantitative basis when evaluating potential COCs.

Arsenic. Arsenic was detected above the regional default background concentration and the JSCS SLV in 2 of 19 discrete, 1 of 7 composite, and 1 of 1 ISM (duplicate only) samples. The discrete and composite samples exceeding the JSCS SLV are located within the area of the ISM sample. Relative to the JSCS SLV, the maximum exceedance ratios (ERs) for the sampling methods ranged from 1.5 to 3.5. Relative to the PRG, ERs ranged up to 8, but the PRG is below the regional default background concentration. Arsenic is bioaccumulative. Arsenic is not a COC in the sediments adjacent to the OU5 riverbank (AOPC 21). Based on infrequent detection, low ER, and arsenic not being a COC in sediment, arsenic is not a COC at OU5.

Cadmium. Cadmium was detected above the regional default background concentration and the JSCS SLV in 0 of 16 discrete and 2 of 7 composite samples. Cadmium was not analyzed in the ISM sample. Relative to the JSCS SLV, the maximum ER was 1.1. The maximum detected concentration of cadmium was less than the PRG. Cadmium is bioaccumulative. Cadmium is a COC in the sediments adjacent to the OU5 riverbank. Based on infrequent detection, low ER, and concentrations less than the PRG, cadmium is not a COC at OU5.

Copper. Copper was detected above the regional default background concentration and the JSCS SLV in 4 of 19 discrete, 1 of 7 composite, and 0 of 1 ISM samples. Relative to the JSCS SLV, the maximum ERs for the sampling methods ranged from 1.8 to 11. Relative to the PRG, ERs ranged up to 9.9. Copper is not bioaccumulative. Copper is not a COC in the sediments adjacent to the OU5 riverbank. Based on detection of copper at up to 11 times the JSCS SLV, copper is a COC at OU5.

Lead. Lead was detected above the regional default background concentration and the JSCS SLV in 7 of 31 discrete, 1 of 7 composite, and 0 of 1 ISM samples. Relative to the JSCS SLV, the maximum ERs for the sampling methods ranged from 5 to 26. Relative to the PRG, only 4 discrete samples exceeded the PRG, with the maximum ER of 4.6. Lead is bioaccumulative. Lead is not a COC in the sediments adjacent to the OU5 riverbank. Based on detection of lead at up to 26 times the JSCS SLV, lead is a COC at OU5.

Zinc. Zinc was detected above the regional default background concentration and the JSCS SLV in 2 of 19 discrete, 1 of 7 composite, and 0 of 1 ISM samples. Relative to the JSCS SLV, the maximum ERs for the sampling methods ranged from 1.5 to 1.8. Relative to the PRG, ERs ranged up to 2.7. Zinc is not bioaccumulative. Zinc is not a COC in the sediments adjacent to the OU5 riverbank. Based on infrequent detection, low ER, and zinc not being a COC in sediment, zinc is not a COC at OU5.

Anthracene. Anthracene was detected above the JSCS SLV in 1 of 28 discrete, 0 of 7 composite, and 0 of 1 ISM samples. Relative to the JSCS SLV, the maximum ER was 2. Anthracene is not bioaccumulative. Anthracene is not a COC in the sediments adjacent to the OU5 riverbank. Based on infrequent detection, low ER, and anthracene not being a COC in sediment, anthracene is not a COC at OU5.

Benzo(g,h,i)perylene. Benzo(g,h,i)perylene was detected above the JSCS SLV in 5 of 28 discrete, 2 of 7 composite, and 1 of 1 ISM samples. Relative to the JSCS SLV, the maximum ERs for the sampling methods ranged from 1.1 to 3.4. Benzo(g,h,i)perylene is not bioaccumulative. Benzo(g,h,i)perylene is not a COC in the sediments adjacent to the OU5 riverbank. Based on the low ER, benzo(g,h,i)perylene not being bioaccumulative, and benzo(g,h,i)perylene not being a COC in sediment, benzo(g,h,i)perylene is not a COC at OU5.

Indeno(1,2,3-cd)pyrene. Indeno(1,2,3-cd)pyrene was detected above the JSCS SLV in 12 of 28 discrete, 3 of 7 composite, and 1 of 1 ISM samples. Relative to the JSCS SLV, the maximum ERs for the sampling methods ranged from 2.5 to 11. Indeno(1,2,3-cd)pyrene is not bioaccumulative. Indeno(1,2,3-cd)pyrene is not a COC in the sediments adjacent to the OU5 riverbank. There is no PRG for indeno(1,2,3-cd)pyrene, but potential exposure in harbor sediments is evaluated with PRGs for high molecular weight PAHs (HPAHs) for ecological impacts and cPAHs for human health impacts. HPAHs were not detected above the PRG in riverbank soil. Based on HPAHs being detected below the PRG, indeno(1,2,3-cd)pyrene not being a COC in sediment, and further evaluation of cPAHs below, indeno(1,2,3-cd)pyrene is not a COC at OU5.

cPAHs. cPAHs were detected above the PRG in 15 of 28 discrete, 4 of 7 composite, and 1 of 1 ISM samples. Relative to the PRG, the maximum ERs for the sampling methods ranged from 3.4 to 13. cPAHs are not bioaccumulative. cPAHs are not COCs in the sediments adjacent to the OU5 riverbank. Based on the relatively frequent detection and detection of cPAHs at up to 13 times the PRG, cPAHs are COCs at OU5.

LPAHs. LPAHs were detected above the PRG in 1 of 28 discrete, 0 of 7 composite, and 0 of 1 ISM samples. Relative to the PRG, the maximum ER was 2.2. LPAHs are not bioaccumulative. LPAHs are not COCs in the sediments adjacent to the OU5 riverbank. Based on the relatively infrequent detection and the low ER, LPAHs are not COCs at OU5.

Aroclor 1260. Aroclor 1260 was detected above the JSCS SLV in 1 of 19 discrete, 0 of 9 composite, and 0 of 1 ISM samples. Relative to the JSCS SLV, the maximum ER was 3.1. Aroclor 1260 is bioaccumulative. Aroclor 1260 is a COC in the sediments adjacent to the OU5 riverbank. Based on the relatively infrequent detection and the low ER, Aroclor 1260 is not a COC at OU5.

Total PCBs. PCBs were detected above the JSCS SLV in 15 of 19 discrete, 7 of 9 composite, and 1 of 1 ISM samples. Relative to the JSCS SLV, the maximum ERs for the sampling methods ranged from 230 to 1600. Relative to the PRG, ERs ranged from 15 to 100. PCBs are bioaccumulative. PCBs are COCs in the sediments adjacent to the OU5 riverbank. Based on frequent detection, detection of PCBs at up to 1600 times the JSCS SLV and 100 times the PRG, PCBs being bioaccumulative, and PCBs being COC in sediment, PCBs are COCs at OU5.

TBT. TBT was detected above the JSCS SLV in 7 of 17 discrete and 3 of 3 composite samples. TBT was not analyzed in the ISM sample. Relative to the JSCS SLV, the maximum ER was 250. The maximum detected concentration of TBT was less than the PRG. TBT is bioaccumulative. TBT is not a COC in the sediments adjacent to the OU5 riverbank. Based on concentrations less than the PRG and TBT not being a COC in sediment, TBT is not a COC at OU5.

Summary of COCs. Based on the above discussion, the COCs for the OU5 riverbank are:

- Copper;
- Lead;
- cPAHs; and
- Total PCBs.

3.4.2 Lines of Evidence Related to Physical Properties of the Riverbank

The SCE Addendum (Ash Creek, 2011) included a detailed evaluation of the physical characteristics of the OU5 riverbank that included evaluation of long-term bank erosion from historical aerial photographs, geotechnical evaluation of overall slope stability, detailed reconnaissance of the riverbank, quantitative evaluation of the potential for surface erosion, and evaluation of potential erosion from river action. The following summarizes the conclusions of these evaluations.

- Historical aerial photographs indicate that there has been no detectable change in the location of the top of the riverbank at OU5 since the island was constructed in the 1920s.
- Slope stability calculations for the OU5 riverbank indicate that the existing slope has an acceptable factor of safety with respect to potential slope failure.
- Reconnaissance of the riverbank determined that the bank is generally covered with dense vegetation or rip rap. Erosion scarps were observed at six locations for a total length of 830 feet (compared to the length of the OU5 riverbank of 2,700 feet). The height of the erosion scarps varied from less than 1 foot up to 6.6 feet. The scarps appear to be the result of wave action from boat wakes.
- The potential for erosion of the riverbank from surface runoff was determined to be negligible.

- Except for the potential for additional erosion of the existing scarps from wave action, the potential for erosion of the riverbank from river action was determined to be negligible.

The overall conclusion is that further erosion of the existing scarps represents the only substantive mechanism for transport of riverbank soil to sediments. The toe elevations of the existing scarps range from 18.5 feet to 26.5 feet NAVD88. Using river stage level data collected over the past 26 years, the river level exceeds elevation 18.5 feet less than 3 percent of the time. Allowing for vessel wakes up to 2 feet in height, the river level is within the range to potentially induce further erosion (i.e., above elevation 16.5 feet) only 5.5 percent of the time. Evaluation of river stage data is presented in Appendix A.

3.4.3 Extent of Soil with Potential for Adverse Effects on Sediments

This section discusses the extent of COCs in riverbank soil with the potential for adverse effects on sediments.

To evaluate potential for adverse effects on sediments, exposure point concentrations were compared to PRGs corresponding to relevant Portland Harbor sediment remedial action objectives (RAOs). There are four Portland Harbor RAOs related to sediments:

- RAO 1, human health direct contact;
- RAO 2, human health bioaccumulation;
- RAO 5, ecological toxicity; and
- RAO 6, ecological bioaccumulation.

Table 12 lists the PRGs corresponding to these RAOs for the COCs.

For RAO 5, relatively immobile organisms (e.g., benthic organisms) are the assumed receptor, so soil concentrations were compared to PRGs on a point-by-point basis.

For RAOs 1, 2, and 6, receptors (people, fish, birds, and mammals) are mobile so it is reasonable and conservative to assume these receptors may be exposed to sediments anywhere along the length of OU5. Therefore, a mean concentration is representative of potential exposure for these receptors. Because judgmental sampling was used to select the discrete and composite sample locations, an area-weighted average concentration was used to evaluate potential exposure for RAOs 1, 2, and 6. Each sample type – discrete and composite – was evaluated separately. In evaluating the area-weighted average, at locations with samples at multiple depths, the maximum concentration at that location was used in the calculation. The ISM sample was collected over approximately one-third of the OU5 riverbank, so the ISM sample was compared directly to the PRGs.

Copper. For copper, there is a PRG only for RAO 5. Therefore the riverbank soil data for copper were evaluated only on a point-by-point basis. Figure 4 shows the extent of copper in riverbank soil. At RB-10, copper exceeds the PRG by a factor of 10. At the other three locations where copper exceeds the PRG, ERs range from 1.6 to 3.4. Based on detection of copper at 10 times the PRG and observed erosion at RB-10, erosion at RB-10 has the potential for adverse effect on sediments.

Lead. For lead, there is a PRG only for RAO 5. Therefore the riverbank soil data for lead were evaluated only on a point-by-point basis. Figure 5 shows the extent of lead in riverbank soil. At RB-10, lead exceeds the PRG by a factor of 4.6. At the other three locations where lead exceeds the PRG, ERs range from 1.1 to 2.3. Based on detection of lead at 4.6 times the PRG and observed erosion at RB-10, erosion at RB-10 has the potential for adverse effect on sediments.

cPAHs. cPAHs have PRGs only for RAOs 1 and 2. Therefore, cPAHs were further evaluated by comparing area-weighted average concentrations to PRGs. Table 13 shows the calculation of cPAH area-weighted average concentrations and comparison to PRGs. The area-weighted averages and ISM result are less than the PRG for RAO 2. For RAO 1, ERs for area-weighted averages range from 1.6 to 2.1, and the ISM ER is 3.4. Based on the low ERs, cPAHs at OU5 are not likely to adversely impact sediments.

Total PCBs. PCBs have PRGs for RAOs 1, 2, 5, and 6. Figure 6 shows comparison of PCBs in riverbank soil to the PRG for RAO 5. PCBs exceed the RAO 5 PRG only at locations RB-9 and RB-10 at ERs of 1.2 and 4.9, respectively. Table 14 shows the calculation of PCB area-weighted average concentrations and comparison to PRGs. The area-weighted averages and the ISM result are less than the PRG for RAO 1. For RAO 2, area-weighted average ERs range from 9 to 12, and the ISM ER is 17. For RAO 6, ERs range from 1.4 to 1.7, and the ISM ER is 2.6. Based on detection of PCBs above the RAO 5 PRG and observed erosion at RB-9 and RB-10, erosion at RB-9 and RB-10 has the potential for adverse effect on sediments. Additionally, based on area-weighted average concentrations of PCBs on the order of 10 times the RAO 2 PRG, erosion elsewhere on the riverbank has the potential for adverse effect on sediments.

3.5 Screen Upland Ecological and Human Health Risks

3.5.1 Ecological

The Port conducted ecological risk assessments (ERAs) for plants, invertebrates, and vertebrate wildlife species for OU5 (Formation 2012, 2013). The ERA concluded that while concentrations of chemicals of potential ecological concern (COPECs) exceeded some risk thresholds, risk of significant adverse effects on overall ecological function and wildlife populations was minimal. The risk to plants and invertebrates from copper, lead, and zinc was unacceptable at several individual sampling locations, and the risk to birds from copper exposure was unacceptable based primarily on detections in the southern end of OU5 (DEQ, 2013).

To further evaluate risk at the southern end of OU5, the ISM sample results were compared to ecological risk-based concentrations. The ISM sample area encompassed the riverbank where the previous grab samples with the elevated metal concentrations (i.e., RB-9 and RB-10) were collected, as well as the riverbank upstream and downstream from that area. Concentrations of copper, lead, and zinc in the ISM sample were detected at concentrations below the corresponding SLVs (Formation Environmental, 2015). Although the ISM sample is not a 90% upper confidence limit on the mean (90UCL) of multiple samples, it is considered representative of exposure across the area from which the subsamples were composited. Considering the ISM sample equivalent to the 90UCL as an estimate of exposure, the results suggest that risk is acceptable for this section of OU5, and further remediation is not needed.

3.5.2 Human Health

Overall human health risk was evaluated for OU2 (when OU5 was part of OU2) and risks were found to be acceptable except for the presence of arsenic in surface soil in the Daimler Trucks leasehold area. A removal action to address the unacceptable risk was completed in early 2015. To update these risk conclusions now that OU5 is separate from OU2, the riverbank data were screened against DEQ risk-based concentrations (RBCs) (DEQ, 2003) for occupational exposure. Arsenic, benzo(a)pyrene, and PCBs were detected above occupational RBCs in at least one riverbank sample. Based on the evaluation summarized in the following paragraphs, no additional areas were identified for source control actions based on upland human health screening.

- **Arsenic.** Arsenic was detected above the regional default background concentration and the RBC in 2 of 19 discrete, 1 of 7 composite, and 1 of 1 ISM (duplicate only) samples. The discrete and composite samples exceeding background are located within the area of the ISM sample. One of the two discrete samples exceeding background is located at RB-10, already identified as an area targeted for source control. Based on completion of the upland remedial action, infrequent detection above background, and one of three areas already targeted for source control, further action related to arsenic is not warranted at OU5.
- **Benzo(a)pyrene.** Benzo(a)pyrene was detected above the RBC in 3 of 28 discrete, 1 of 7 composite, and 0 of 1 ISM samples. The ERs range from 1.1 to 2.9. One of the three discrete samples exceeding the RBC is located at RB-10, already identified as an area targeted for source control. Based on overall acceptable upland risk for benzo(a)pyrene, infrequent detection above RBC, relatively low ER, and one of three areas already targeted for source control, the overall exposure point concentration for benzo(a)pyrene is acceptable and further action related to benzo(a)pyrene risk for upland human health is not warranted at OU5.
- **PCBs.** PCBs were detected above the RBC in 1 of 19 discrete, 0 of 9 composite, and 0 of 1 ISM samples. The sample exceeding the RBC is located at RB-10, already identified as an area targeted for source control. Based on the area exceeding the RBC already targeted for source

control, the overall exposure point concentration for PCBs is acceptable and further action related to PCB risk for upland human health is not warranted at OU5.

3.6 Summary of Areas Targeted for Source Control

The following areas are targeted for evaluation of source control measures.

Erosion Scarps at RB-9 and RB-10. At RB-9 and RB-10, copper, lead, and PCBs exceed PRGs for ecological toxicity (PRGs for RAO 5) by factors of up to 10. The maximum detected concentrations of 10 of 13 COPCs and 4 of 4 COCs were detected at RB-10, and the two highest concentrations of PCBs and lead were detected at RB-9 and RB-10. Given the observation of historical erosion, multiple chemicals exceeding ecological toxicity PRGs, and RB-9 and RB-10 being the location of higher relative detections for most COPCs and all COCs, the erosion scarps at RB-9 and RB-10 should be targeted for source control measures.

In the event of source control measures at RB-9 and RB-10, the following summarizes the revised ERs for each COPC with data from RB-9 and RB-10 removed from the evaluation. These ERs are an indicator of the residual risk following source control measures at RB-9 and RB-10.

COPC	PRG and Background Exceedances	Range of ERs Greater than 1
Arsenic	3 of 23	1.5 – 3.5
Cadmium	0 of 19	--
Copper	2 of 23	1.6 – 3.4
Lead	2 of 35	1.1 – 1.8
Zinc	3 of 23	1.4 – 2.7
Anthracene	--	--
Benzo(g,h,i)perylene	--	--
Indeno(1,2,3-cd)pyrene	--	--
cPAHs	17 of 32	1.6 – 1.7*
LPAHs	0 of 32	--
Aroclor 1260	--	--
PCBs	19 of 25	1.7 – 12*
TBT	0 of 18	--

* Based on area-weighted averages with RB-9 and RB-10 removed; excludes ISM sample because RB-9 and RB-10 located within area of the ISM sample (see Tables 13 and 14).

Other Erosion Scarps. PCBs were detected above PRGs throughout the length of the riverbank. The following summarizes the comparison of PCB data to PRGs.

- RAO 1 PRG (370 µg/kg) – This RAO addresses human health, direct contact. Area-weighted average concentrations and the ISM sample result are below the RAO 1 PRG.
- RAO 2 PRG (6 µg/kg) – This RAO addresses human health, bioaccumulation exposure. Area-weighted average concentrations and the ISM concentration (Table 14) range from 56 to 104 µg/kg, exceeding the PRG by factors of 9 to 17. Removal of RB-9 and RB-10 from the discrete sample area-weighted average calculation reduces the ER to 5.2.
- RAO 5 PRG (126 µg/kg) – This RAO addresses ecological toxicity. PCBs exceed the RAO 5 PRG only at locations RB-9 and RB-10 at ERs of 1.2 and 4.9, respectively. After removal of RB-9 and RB-10 from the dataset, PCB concentrations are below RAO 5.
- RAO 6 PRG (40 µg/kg) – This RAO addresses ecological bioaccumulation. Area-weighted average concentrations and the ISM concentration exceed the PRG by factors of 1.4 to 2.6. Removal of RB-9 and RB-10 from the discrete sample area-weighted average calculation reduces the ER to less than one.

Based on this summary, source control measures at RB-9 and RB-10 would result in PCB concentrations throughout the riverbank meeting the PRGs for RAO 1, RAO 5, and RAO 6 for discreet sample results.[3] For RAO 2, the discrete sample area-weighted average after removal of RB-9 and RB-10 (31 µg/kg) would exceed the PRG by a factor of 5. As a result, erosion of bank soil throughout the riverbank has the potential to adversely impact sediment. Given that three of four exposure pathways/receptors would be acceptable, the overall concentration after addressing RB-9 and RB-10 only moderately exceeds the PRG, and that potential for erosion is limited to infrequent higher river levels (less than 6 percent of the time – see Section 3.4.2), source control measures to address other areas of the OU5 riverbank can be deferred until implementation of the in-water remedy at Swan Island.

4.0 Source Control Objective and Evaluation Criteria

4.1 Source Control Objective

The Source Control Objective (SCO) for the OU5 riverbank soil is to prevent erosion of soil into the river at concentrations that could result in sediment concentrations above remediation goals following cleanup of the Portland Harbor.

[3] Note that addressing RB-9 and RB-10 would improve the composite sample area-weighted average and ISM sample results, but these improvements cannot be directly evaluated.

4.2 Evaluation Criteria

The riverbank source control alternatives were evaluated using the criteria referenced in JSCS for Source Control Alternative Evaluation and Design. These criteria are effectiveness, implementability, and relative cost as described below in this section.

4.2.1 Effectiveness

This criterion includes both the long-term effectiveness of the technology to prevent soils from eroding into the river and the feasibility of minimizing short-term risk (i.e., implementation risk) of erosion during construction, as further described below. In addition, viable alternatives must provide a threshold level of environmental protection that prevents erosion of impacted soils to the aquatic environment.

- **Long-Term Effectiveness.** The effectiveness criterion considers the ability of an alternative to provide long-term environmental protection. An effective technology must be able to withstand scour and erosion that could destabilize the bank.
- **Implementation Risk.** The objective of this criterion is to minimize short-term risks to the environment associated with construction activities. Impacted soil may be exposed by re-grading certain parts of the bank, creating a risk of erosion into the aquatic environment. Although such impacts should be avoided to the extent practicable, in some cases it may be necessary to tolerate some amount of short-term environmental risk to gain long-term environmental protection. Engineering controls (e.g., silt fences) are used in these cases to reduce implementation risk.

4.2.2 Implementability

The implementability criterion considers a number of factors that affect the practicability of constructing a particular alternative. These factors include the following:

- **Operational Constraints.** Upland and waterside operations must not be compromised by the technology. For example, the integrity of adjacent structures and rights of way must not be undermined by excessive removal of the bank.
- **Consistency with Adjacent Remedial Actions.** The proposed alternative must be consistent with the adjacent upland and in-water remedies, to the extent the design of these final remedies can be anticipated, as well as any proposed remedial actions associated with the Portland Harbor Superfund site.
- **Permitting.** This factor considers the ease of obtaining permits for the source control alternative, or the ease of fulfilling the substantive requirements of permits exempted under the Comprehensive Environmental Response, Compensation, and Liability Act and/or DEQ rules.

- **Consistency with Current and Future Land Use.** A source control alternative should not conflict with existing or anticipated future land use, especially water-dependent land use. For example, heavy industrial waterfront usage may conflict with the use of shallow, bioengineered slopes and wide riparian buffer zones.
- **Sustainability.** Sustainability considers the overall use of resources associated with a technology including energy and natural resources used to manufacture, install, and maintain the elements of the technology.

4.2.3 Cost

The relative cost to implement a source control alternative is developed at a conceptual level by comparing relative unit costs for various technologies.

5.0 Extent of Riverbank Warranting Source Control

Figure 7 shows the proposed source control measure (SCM) areas. As summarized in Section 3.6, erosion of soil throughout the riverbank has the potential to adversely impact sediment. However, most of the riverbank is protected from erosion by dense vegetation or rip rap. Exceptions are the areas shown on the figure, corresponding to the existing erosion scarps at or above the OLHW. Erosion features I, J, L, M, and N are targeted for source control. These features are described as follows:

- I – Erosion scarp located near the OLHW (toe elevation of 18.8 to 19.5 feet NAVD88), 35 feet long, and up to 1.5 feet high (but less than 6 inches high for most of its length).
- J – Erosion scarp located below and above the OLHW (toe elevation of 18.5 to 25.5 feet NAVD88), 635 feet long, and up to 6.6 feet high (average height of 3.3 feet).
- L – Erosion scarp located above the OLHW (toe elevation of 23.0 to 24.4 feet NAVD88), 56 feet long, and up to 3.0 feet high.
- M – Erosion scarp located above the OLHW (toe elevation of 23.8 to 25.4 feet NAVD88), 53 feet long, and up to 2.7 feet high.
- N – Erosion scarp located above the OLHW (toe elevation of 24.6 to 26.5 feet NAVD88), 49 feet long, and up to 2.0 feet high.

6.0 Technology Evaluation and Source Control Alternatives Development

This section describes and evaluates the source control technologies applicable to a SCM for the riverbank.

6.1 Screening of General Approaches

General approaches for SCMs at the OU5 riverbank include the following:

- No Action;
- Institutional Controls;
- Removal;
- Containment/Engineering Controls;
- Biological Treatment; and
- Physical/Chemical/Thermal Treatment.

No Action. A detailed evaluation of the need for source control was prepared in the SCE/SCE Addendum (Ash Creek 2010 and 2011) and the discussion in Section 3 that determined that source control was appropriate at OU5. Therefore, a No Action alternative was not retained.

Institutional Controls. Institutional Controls consist of physical or legal barriers to prevent access to areas of concern. Institutional Controls would not prevent erosion of soil to surface water so were eliminated from further consideration.

Removal. Potentially erodible soils could be excavated and disposed of in an off-site landfill. After excavation, the bank would be stabilized against potential erosion from wave, current, or wind action. To provide a range of source control options, removal was retained for further consideration.

Containment/Engineering Controls. Technologies in this category include capping and stabilization. These technologies prevent direct contact with (for terrestrial receptors) and erosion of surface soils. These technologies would be required with any other approach, but are capable of achieving the project objectives without other technologies. The studies completed as part of the SCE/SCE Addendum (Ash Creek, 2010 and 2011) demonstrated that the overall riverbank is stable and that well-established riprap and vegetation are successful in preventing surface erosion. Therefore, stabilization technologies were retained for further consideration.

Biological Treatment. Some of the source control COCs such as metals are not amenable to biological treatment under normal circumstances. Furthermore, biological treatment can take time during which the soils would be susceptible to erosion. For these reasons, biological treatment was eliminated from further consideration.

Physical/Chemical/Thermal Treatment. Chemical and thermal treatment are not compatible with some of the source control COCs. Physical treatment (e.g., solidification) could achieve the project objectives at high relative cost, but would not be compatible with City Greenway standards (the resulting condition would not be suitable for planting native species). Therefore, physical/chemical/thermal treatments were eliminated from further consideration.

6.2 Description of Source Control Technologies

To address erosion of the OU5 riverbank, removal and bank stabilization technologies were considered for application: excavation/fill with re-vegetation, slope re-grading and re-vegetation, riprap armoring, articulated concrete block (ACB) armoring, and a geosynthetic cellular confinement system (CCS).

6.2.1 Excavation/Fill with Re-Vegetation

Riverbank soil targeted for source control could be removed for disposal in an off-site landfill. For purposes of the evaluation, it was assumed that 2 feet of soil would be removed. This is the likely minimum amount that would be removed. Greater excavation depths would result in higher costs for this technology. Following excavation, the soil would be re-graded and stabilized. Above the flood stage elevation (21.6 feet NAVD88), re-vegetation (as discussed in Section 6.2.2) would be used to stabilize the surface. Below the flood stage elevation, armoring (one of the technologies discussed in Sections 6.2.3 through 6.2.5) would be used to stabilize the surface.

6.2.2 Slope Re-grading and Re-vegetation

Slopes along the bank are over-steepened at the erosion scarps and re-grading will improve long-term stability. Based on performance of the existing bank, soil slopes of 33 percent or flatter that are vegetated would remain intact above the flood stage elevation. Vegetated geosynthetics (e.g., turf mats) can be installed to enhance the vegetation process and protect surface soils from erosion prior to germination. Below the flood stage elevation, soils would remain susceptible to surface erosion from river flow and wave action regardless of slope steepness. In some cases, large boulders and woody debris are used to protect portions of a slope that regularly become inundated with water; however, care must be taken to ensure the slope toe is sufficiently buttressed. Therefore, slope re-grading/re-vegetation has been carried forward in the bank stabilization analysis as a viable technology.

6.2.3 Riprap Armoring

Traditional riprap armoring consists of a blanket of rock material sized to resist river currents and wave action. It is a flexible solution that is able to fit the slope and shape of an existing shoreline. It is also tolerant to changes in subsurface soils due to settlement and other forces. In general, riprap slopes can be maintained at a steeper grade than re-vegetated soil slopes and also provide resistance against surface erosion from water flow. This method is extremely durable in the long-term and provides high resistance to propeller wash and vessel wakes associated with a working waterfront. It is also possible to plant vegetation in the rocks to further stabilize the slope and enhance the slope appearance and habitat.

6.2.4 Articulated Concrete Block Armoring

ACB mats serve as a flexible revetment system that provides resistance to high flow velocities, effective erosion control, and can also be backfilled with topsoil and planted to maintain a natural appearance. ACB mats generally consist of a grid of individual pre-cast concrete blocks that are attached to one another with a web of stainless steel cables. The grids are placed flat across the entire portion of the bank that is subject to erosion. These blocks can be manufactured with open or closed cells. Open-cell ACBs are often planted, and some systems allow for the removal of individual blocks to accommodate larger vegetation. ACB mats are relatively thin, ranging in thickness from 4- to 9-inch blocks, thus resulting in less material placement in comparison to riprap armoring. ACB mats would be a suitable technology.

6.2.5 Geosynthetic Cellular Confinement Systems

Like open-cell ACB systems, geosynthetic CCSs provide an opportunity to combine an engineered slope stabilization technology with native vegetation that enhances habitat and long-term slope stability. CCSs are typically three-dimensional structures made of polyethylene that form open-ended cylinders 3 to 12 inches deep. Each cell acts as a small dam that allows water to pass over the top while holding in place the soil contained inside the cell. Vegetation may be planted in the upper bank cells. In addition to aesthetics, vegetation also helps to reduce the potential for erosion as the plants serve as an anchor. Because the walls may be perforated, roots are allowed to grow through the system, further enhancing the erosion protection. The perforations also allow lateral drainage through the system, enhancing performance of the CCS in submerged conditions. On the lower bank, the cells would be filled with gravel to resist the forces of ship waves and currents and to ensure that return flow is not prohibited.

The CCS option can be implemented in two ways: on a prepared slope to create a stabilized surface that can be vegetated (similar to the ACB application); or in horizontal layers to create a mechanically stabilized earth (MSE) wall with a face that can be vegetated. The existing slopes are on the order of 3:1 (horizontal:vertical), so MSE wall segments should not be required. The slope application of the CCS option would perform similarly to the ACB armoring option and result in a re-vegetated slope above the flood stage elevation. Also like the ACB application, initial grading of the slope would be required to ensure voids were not present below the CCS.

6.3 Evaluation of Source Control Technologies

The potentially applicable source control technologies were evaluated based on the criteria given in Section 4.2. Re-grading and re-vegetation would be used with any of the other technologies, but re-vegetation is suitable only for the zones above the flood stage. Therefore, the following evaluation focuses on the other technologies for use below flood stage.

6.3.1 Effectiveness

Each of the technologies addresses the root cause of instability and would have relatively low risks of contamination during construction. Removal would be the most effective because there would be no risk of chemical impacts even if the surface stabilization technology were to fail. Each of the stabilization technologies would provide adequate erosion control, but riprap would most likely have the greatest lifespan due to its ability to provide long-term resistance against surface erosion from water flow and greater flexibility. In the long-term life of the SCM, CCS has a higher potential to be susceptible to scour and erosion. For these reasons, riprap was deemed to be more effective than ACB and CCS.

6.3.2 Implementability

In terms of ease of construction, riprap and ACB are the simplest to implement and the materials are readily attainable within the vicinity of the project area. The ACB and CCS alternatives provide slightly better re-vegetation opportunities. In-water remedies for adjacent sediment management areas are likely to consist of limited action technologies (such as natural recovery or capping). Each of the technologies would be compatible with these approaches. The work should occur above the OLHW, but some work below the OLHW is possible depending on the final design of the remedy. Riprap already exists throughout the OU2 riverbank, thus making riprap the technology most compatible with existing conditions. Furthermore, given the relatively small size of the source control areas, use of riprap is more feasible than the other technologies. There is not expected to be significant differences between the technologies with respect to permitting or sustainability. For these reasons, riprap was deemed more implementable than the other stabilization technologies. Removal is the least implementable technology because it includes both excavation and fill in addition to the need for a stabilization technology.

6.3.3 Cost

Based on professional experience in the Portland Harbor area, riprap would cost on the order of $4 per square foot and ACB or CCS would cost on the order of $7 to $15 per square foot. Assuming an excavation depth of 2 feet, excavation and fill would cost on the order of $10 per square foot, plus the cost of the surface stabilization.

7.0 Recommended Source Control Measure

Based on the results of this evaluation, the recommended source control measure for the OU5 riverbank soils is re-grading of the erosion areas followed by surface stabilization using re-vegetation above the flood elevation and riprap armoring below the flood elevation. This alternative was selected because it provides a low-cost, long-term erosion control solution; it is highly implementable; and it is compatible with existing conditions and potential in-water remediation. A schematic design for the selected alternative is presented on Figure 8.

Given the multiple COCs above PRGs and the relatively higher ERs, the source control measure should be implemented as soon as practicable for the erosion scarps at RB-9 and RB-10. The remaining erosion scarps should be addressed in conjunction with the in-water remedy for Swan Island. To verify that this remedy is protective until implementation of the in-water remedy, the riverbank should be monitored after significant flood events but not less than every other year for evidence of continued erosion at existing scarps or new erosion elsewhere.

8.0 References

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Tables

Table 1 - Riverbank Soil Analytical Results: Discrete Metals (mg/kg)
SIUF - OU2
Portland, Oregon

Outfall Pipe ID:	WR-399	WR-399	WR-399	CG-26	CG-26	CG-26	CG-27	CG-27	CG-27	WR-159a	WR-159a	WR-159a			
Sample ID:	RB-4a	RB-4b	RB-4c	RB-5a	RB-5b	RB-5c	RB-6a	RB-6b	RB-6c	RB-7a	RB-7b	RB-7c	Background	Portland Harbor	JSCS
Sample Date:	10/1/2008	10/1/2008	10/1/2008	10/1/2008	10/1/2008	10/1/2008	10/1/2008	10/1/2008	10/1/2008	10/1/2008	10/1/2008	10/1/2008	Metals	PRG	SLV
Metals (mg/kg)															
Arsenic	--	--	--	--	--	--	--	--	--	--	--	--	8.8	3	7
Cadmium	--	--	--	--	--	--	--	--	--	--	--	--	0.63	3.5	1
Copper	--	--	--	--	--	--	--	--	--	--	--	--	34	165	149
Lead	27.2	170	91.4	30.1	15.2	6.94	58.2	87.5	33.6	84.2	104	18.5	79	96	17
Zinc	--	--	--	--	--	--	--	--	--	--	--	--	180	315	459

Sample ID:	RB-8a	RB-8b	RB-9a	RB-9b	RB-10a	RB-10b	RB-11a	RB-11b	RB-12a	RB-12b	RB-13a	RB-13b	RB-14a	RB-14b	RB-15a	RB-15b	Background	Portland Harbor	JSCS
Sample Date:	10/6/2011	10/6/2011	10/6/2011	10/6/2011	10/6/2011	10/6/2011	10/6/2011	10/6/2011	10/6/2011	10/6/2011	10/6/2011	10/6/2011	10/6/2011	10/6/2011	10/6/2011	10/6/2011	Metals	PRG	SLV
Metals (mg/kg)																			
Arsenic	24.6	3.7	7.0	6.7	5.3	24.1	3.7	4.1	4.0	3.0	2.2	2.0	5.4	5.9	4.2	7.0	8.8	3	7
Cadmium	0.41	0.084	0.20	0.16	0.13	0.46	0.13	0.10	0.19	0.082	0.089	0.10	0.22	0.21	0.15	0.29	0.63	3.5	1
Copper	112	60.1	298	284	112	1,640	57.2	125	61.4	42.4	25.8	567	46.7	62.5	50.7	103	34	165	149
Lead	77.6	21.4	225	78.2	35.0	439	23.2	42.6	24.6	17.1	7.4	12.0	15.4	51.3	14.1	53.3	79	96	17
Zinc	428	98.0	206	187	110	708	116	107	127	65.4	42.3	77.2	114	118	83.1	129	180	315	459

Sample ID:	OU5-SS-02	OU5-SS-04	OU5-SS-06	Background	Portland Harbor	JSCS
Sample Date:	8/14/2014	8/14/2014	8/14/2014	Metals	PRG	SLV
Metals (mg/kg)						
Arsenic	3.4	4.65	3.77	8.8	3	7
Cadmium	--	--	--	0.63	3.5	1
Copper	94.0	60.6	72.3	34	165	149
Lead	46.4	22.0	30.4	79	96	17
Zinc	200	204	691	180	315	459

Notes:

1. Metals analysis by EPA 6000/7000 Series Methods.
2. mg/kg = milligrams per kilogram (parts per million).
3. Background Metals = DEQ, Background Levels of Metals in Soils for Cleanups. March 20, 2013.
4. Portland Harbor PRG = Preliminary Remediation Goal proposed by EPA April 11, 2014 (RAO 5, Ecological Toxicity).
5. JSCS SLV = Portland Harbor Joint Source Control Strategy Table 3-1: Screening Level Values for Soil/Storm Water Sediment (7/16/07 Revision).
6. Box indicates that the reported concentration exceeds the background level and Portland Harbor PRG.
7. Shading indicates that the reported concentration exceeds the background level and JSCS SLV.
8. -- = Not analyzed or not available.

Table 2 - Riverbank Soil Analytical Results: Composite Metals (mg/kg)
SIUF - OU2
Portland, Oregon

Outfall Pipe ID:	WR-164	WR-159	WR-160	WR-399	CG-26	CG-27	WR-159a			
Sample ID:	RB-1 Composite	RB-2 Composite	RB-3 Composite	RB-4 Composite	RB-5 Composite	RB-6 Composite	RB-7 Composite	Background Metals	Portland Harbor PRG	JSCS SLV
Sample Date:	9/26/2006	9/26/2006	9/26/2006	10/1/2008	10/1/2008	10/1/2008	10/1/2008			
Metals (mg/kg)										
Antimony	0.93	0.4	0.35	0.35	0.37	0.27	0.63	0.56	--	64
Arsenic	12.2	3.8	7	3.4	2.7	3.1	2.9	8.8	3	7
Cadmium	1.04	0.46	0.48	0.238	0.763	1.11	0.189	0.63	3.5	1
Chromium	29	19.9	22	13.6	13.8	14.9	22.9	76	90	111
Copper	271	92.4	96.3	65.9	33.3	57.7	71.3	34	165	149
Lead	85.6	43.2	36	41.3	20.1	42.6	57.5	79	96	17
Nickel	26.8	16.9	20.3	15.0	17.9	16.6	24.6	47	--	48.6
Silver	0.19	0.09	0.14	0.05	0.04	0.06	0.07	0.82	--	5
Zinc	835	174	264	153	246	359	121	180	315	459

Notes:
1. Metals analysis by EPA 6000/7000 Series Methods.
2. mg/kg = milligrams per kilogram (parts per million).
3. Background Metals = DEQ, Background Levels of Metals in Soils for Cleanups. March 20, 2013.
4. Portland Harbor PRG = Preliminary Remediation Goal proposed by EPA April 11, 2014 (RAO 5, Ecological Toxicity).
5. JSCS SLV = Portland Harbor Joint Source Control Strategy Table 3-1: Screening Level Values for Soil/Storm Water Sediment (7/16/07 Revision).
6. Box indicates that the reported concentration exceeds the background level and Portland Harbor PRG.
7. Shading indicates that the reported concentration exceeds the background level and JSCS SLV.
8. -- = Not analyzed or not available.

Table 3 - Riverbank Soil Analytical Results: ISM Metals (mg/kg)
SIUF - OU2
Portland, Oregon

Sample ID:	OU5-ISM- <2mm post grind	Dupe	Background	Portland Harbor	JSCS
Sample Date:	8/14/2014	8/14/2014	Metals	PRG	SLV
Metals (mg/kg)					
Arsenic	8.55	10.5	8.8	3	7
Copper	92.9	99.0	34	165	149
Lead	41.9	41.4	79	96	17
Zinc	232	259	180	315	459

Notes:

1. Metals analysis by EPA 6000/7000 Series Methods.
2. mg/kg = milligrams per kilogram (parts per million).
3. Background Metals = DEQ, Background Levels of Metals in Soils for Cleanups. March 20, 2013.
4. Portland Harbor PRG = Preliminary Remediation Goal proposed by EPA April 11, 2014 (RAO 5, Ecological Toxicity).
5. JSCS SLV = Portland Harbor Joint Source Control Strategy Table 3-1: Screening Level Values for Soil/Storm Water Sediment (7/16/07 Revision).
6. Box indicates that the reported concentration exceeds the background level and Portland Harbor PRG.
7. Shading indicates that the reported concentration exceeds the background level and JSCS SLV.
8. -- = Not analyzed or not available.

Table 4 - Riverbank Soil Analytical Results: Discrete Polycyclic Aromatic Hydrocarbons (µg/kg)
SIUF - OU2
Portland, Oregon

Outfall Pipe ID:	WR-164	WR-164	WR-164	WR-159	WR-159	WR-159	WR-160	WR-160	WR-160		
Sample ID:	RB-1a	RB-1b	RB-1c	RB-2a	RB-2b	RB-2c	RB-3a	RB-3b	RB-3c	Portland Harbor	JSCS
Sample Date:	9/26/2006	9/26/2006	9/26/2006	9/26/2006	9/26/2006	9/26/2006	9/26/2006	9/26/2006	9/26/2006	PRG[9]	SLV
PAHs (µg/kg)											
Acenaphthene	3.1	<2.7	2.9	<2.6	11	3.5	<2.6	<2.8	17	--	300
Acenaphthylene	28	34	28	19	84	33	15	8.8	23	--	200
Anthracene	12	13	14	7.2	41	16	9	5.5	49	--	845
Benz(a)anthracene	61	69	63	50	230	110	36	40	110	--	1,050
Benzo(a)pyrene	140	180	150	130	520	230	79	64	180	--	1,450
Benzo(b)fluoranthene	140	220	180	110	520	230	76	69	170	--	--
Benzo(g,h,i)perylene	260	330	260	180	720	330	130	87	190	--	300
Benzo(k)fluoranthene	110	140	120	85	380	160	61	57	110	--	13,000
Chrysene	120	160	140	95	430	190	69	62	210	--	1,290
Dibenz(a,h)anthracene	21	30	25	15	77	36	14	14	35	--	1,300
Dibenzofuran	2.9	<2.7	2.7	<2.6	6.6	3.4	4.3	<2.8	7.1	--	--
Fluoranthene	150	150	150	120	500	230	93	59	210	--	2,230
Fluorene	<2.8	<2.7	2.6	<2.6	9.2	2.8	<2.6	<2.8	15	--	536
Indeno(1,2,3-cd)pyrene	210	270	210	150	660	270	110	80	160	--	100
1-Methylnaphthalene	--	--	--	--	--	--	--	--	--	--	--
2-Methylnaphthalene	5.6	4	3.6	<2.6	11	5.4	4.8	<2.8	12	--	200
Naphthalene	11	7.4	6.9	4.5	19	10	6.8	3.5	13	--	561
Phenanthrene	46	33	42	22	150	58	36	17	190	--	1,170
Pyrene	220	240	200	170	690	350	120	83	290	--	1,520
cPAHs (BaP Eq)	206	271	224	179	749	332	117	98	262	106	--
Total PAHs	1,541	1,880	1,601	1,158	5,059	2,268	864	650	1,991	23,000	--
Total LPAHs	109	91	103	53	332	132	76	35	326	1,600	--
Total HPAHs	1,432	1,789	1,498	1,105	4,727	2,136	788	615	1,665	150,000	--

Please refer to notes at end of table.

Table 4 - Riverbank Soil Analytical Results: Discrete Polycyclic Aromatic Hydrocarbons (µg/kg)
SIUF - OU2
Portland, Oregon

Sample ID:	RB-8a	RB-8b	RB-9a	RB-9b	RB-10a	RB-10b	RB-11a	RB-11b	RB-12a	RB-12b	RB-13a	RB-13b	RB-14a	RB-14b	RB-15a	RB-15b	Portland Harbor PRG[9]	JSCS SLV
Sample Date:	10/6/2011	10/6/2011	10/6/2011	10/6/2011	10/6/2011	10/6/2011	10/6/2011	10/6/2011	10/6/2011	10/6/2011	10/6/2011	10/6/2011	10/6/2011	10/6/2011	10/6/2011	10/6/2011		
PAHs (µg/kg)																		
Acenaphthene	5.8	<1.2	10.6	6.1	<1.2	155	2.3	2.1	2	<1.2	<1.2	<1.2	1.5	2.1	34.4	50.2	--	300
Acenaphthylene	95	3.8	14.9	18.7	5.9	183	6.3	10.0	4.3	7.2	<1.2	2.2	3.7	13.8	47.1	76.2	--	200
Anthracene	48.4	4.5	36.7	45.8	8.5	1,690	10.9	8.7	6.6	6.2	<1.2	2	6	23.6	36.1	94.5	--	845
Benz(a)anthracene	133	14.4	111	106	37.9	705	29.5	32.2	21.8	29.7	<1.1	7.2	19.2	70.4	64.5	106	--	1,050
Benzo(a)pyrene	293	22.1	127	142	51.6	783	40.4	54.7	35.3	40.4	<1.3	10.0	21.8	80.5	72.4	109	--	1,450
Benzo(b)fluoranthene	339	30.8	181	179	70.0	1,140	61.7	80.5	51.4	53.6	1.6	13.2	36.0	87.4	68.9	120	--	--
Benzo(g,h,i)perylene	368	24.5	118	154	47.5	1,020	43.4	76.4	34.8	38.7	2.1	12.0	19.9	61.0	50.1	105	--	300
Benzo(k)fluoranthene	97.7	10.3	56.4	71.3	26.2	409	17.4	28.5	15.9	18.6	<1.2	4.5	13.1	32.4	29.8	44.3	--	13,000
Chrysene	194	18.4	108	109	41.5	667	37.5	41.6	28.7	32.1	<1.3	8.5	29.0	71.1	62.8	133	--	1,290
Dibenz(a,h)anthracene	42.8	5.3	33.2	34.5	13.6	236	10.3	20.9	7.8	10.3	<0.90	2.3	4.3	14.3	10.3	12.7	--	1,300
Dibenzofuran	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Fluoranthene	358	23.2	175	158	54.4	1,640	49.5	39.2	44.1	27.9	1.5	10.2	35.1	100	129	243	--	2,230
Fluorene	7.1	<1.5	12.7	10.2	1.6	246	4.4	2.4	2.1	1.8	<1.5	<1.5	2.2	4.7	25.5	81.0	--	536
Indeno(1,2,3-cd)pyrene	321	25.0	128	150	52.1	1,130	44.5	78.0	36.5	40.6	1.4	11.1	20.1	59.0	49.5	84.4	--	100
1-Methylnaphthalene	3.1	<1.3	7	4.1	1.5	36.6	1.4	2.1	<1.4	<1.3	<1.3	<1.3	2	2.7	33.8	46.3	--	
2-Methylnaphthalene	5	<1.3	12.1	7.8	1.3	93.1	2.5	2	2.2	2.1	<1.3	<1.3	3.7	4.7	62.1	98.4	--	200
Naphthalene	7.9	<2.8	21.8	12.5	<2.7	124	<2.8	2.8	4	<2.8	<2.8	<2.8	6.9	6.1	256	313	--	561
Phenanthrene	131	7.8	95.5	62.4	15.9	1,060	24.6	20.2	21.2	11.5	<1.2	4.2	22.2	47.6	145	339	--	1,170
Pyrene	411	24.9	149	146	48.9	1,460	47.4	43.3	38.3	33.4	1.6	11.8	33.2	2	150	449	--	1,520
cPAHs (BaP Eq)	420	35	204	222	82	1,331	65	96	55	64	0.3	16	34	117	102	154	106	--
Total PAHs	2,861	215	1,398	1,417	478	12,778	434	546	357	354	8.2	99	280	683	1,327	2,505	23,000	--
Total LPAHs	303	16	211	168	35	3,588	52	50	42	29	0	8	48	105	640	1,099	1,600	--
Total HPAHs	2,558	199	1,187	1,250	444	9,190	382	495	315	325	8.2	91	232	578	687	1,406	150,000	--

Please refer to notes at end of table.

Table 4 - Riverbank Soil Analytical Results: Discrete Polycyclic Aromatic Hydrocarbons (µg/kg)
SIUF - OU2
Portland, Oregon

Sample ID: / Sample Date:	OU5-SS-02 8/14/2014	OU5-SS-04 8/14/2014	OU5-SS-06 8/14/2014	Portland Harbor PRG[9]	JSCS SLV
PAHs (µg/kg)					
Acenaphthene	11.2	<10.5	<10.0	--	300
Acenaphthylene	35.2	<10.5	<10.0	--	200
Anthracene	76.9	<10.5	10.2	--	845
Benz(a)anthracene	277	45.1	41.9	--	1,050
Benzo(a)pyrene	301	63.7	47.8	--	1,450
Benzo(b)fluoranthene	--	--	--	--	--
Benzo(g,h,i)perylene	174	43.2	30.7	--	300
Benzo(k)fluoranthene	--	--	--	--	13,000
Benzo(b+k)fluoranthene	567	128	102	--	--
Chrysene	332	66.6	57.4	--	1,290
Dibenz(a,h)anthracene	48.1	<10.5	<10.0	--	1,300
Dibenzofuran	--	--	--	--	--
Fluoranthene	571	87.3	74.1	--	2,230
Fluorene	19.4	<10.5	<10.0	--	536
Indeno(1,2,3-cd)pyrene	197	47.1	34	--	100
1-Methylnaphthalene	<9.83	<10.5	<10.0	--	
2-Methylnaphthalene	<9.83	<10.5	<10.0	--	200
Naphthalene	<9.83	<10.5	<10.0	--	561
Phenanthrene	327	44.0	39.7	--	1,170
Pyrene	575	82.8	73.3	--	1,520
cPAHs (BaP Eq)	455	86	66	106	--
Total PAHs	3,501	608	511	23,000	--
Total LPAHs	736	89	92	1,600	--
Total HPAHs	2,765	519	419	150,000	--

Notes:

1. Polycyclic Aromatic Hydrocarbons (PAHs) by U.S. Environmental Protection Agency (EPA) Method 8270-SIM. cPAHs - carcinogenic PAHs; LPAHs - low molecular weight PAHs, HPAHs - high molecular weight PAHs
2. µg/kg = micrograms per kilogram (parts per billion).
3. Portland Harbor PRG = Preliminary Remediation Goal proposed by EPA April 11, 2014 (cPAHs - Human Health direct contact; others Ecological toxicity).
4. JSCS SLV = Portland Harbor Joint Source Control Strategy Table 3-1: Screening Level Values for Soil/Storm Water Sediment (7/16/07 Revision).
5. -- = Not analyzed or not available.
6. < = Not detected above the Method Reporting Limit (MRL).
7. Box indicates that the reported concentration exceeds the Portland Harbor PRG.
8. Shading indicates that the reported concentration exceeds the JSCS SLV.
9. Total HPAHs PRG is mg/(kg-%fines)

Table 5 - Riverbank Soil Analytical Results: Composite Polycyclic Aromatic Hydrocarbons (µg/kg)
SIUF - OU2
Portland, Oregon

Outfall Pipe ID:	WR-164	WR-159	WR-160	WR-399	CG-26	CG-27	WR-159a		
Sample ID:	RB-1 Composite	RB-2 Composite	RB-3 Composite	RB-4 Composite	RB-5 Composite	RB-6 Composite	RB-7 Composite	Portland Harbor PRG[9]	JSCS SLV
Sample Date:	9/26/2006	9/26/2006	9/26/2006	10/1/2008	10/1/2008	10/1/2008	10/1/2008		
PAHs (µg/kg)									
Acenaphthene	<2.7	5.1	<2.8	8.9	0.87	1.2	0.69	--	300
Acenaphthylene	41	61	16	1.8	2.2	2.0	4.1	--	200
Anthracene	14	24	9.1	9.3	3.5	2.2	4.5	--	845
Benz(a)anthracene	68	140	45	45	23	17	22	--	1,050
Benzo(a)pyrene	170	320	94	70	42	29	43	--	1,450
Benzo(b)fluoranthene	210	310	87	100	61	35	49	--	--
Benzo(g,h,i)perylene	360	490	150	81	64	33	70	--	300
Benzo(k)fluoranthene	160	240	70	33	15	12	17	--	13,000
Chrysene	160	260	82	79	27	26	35	--	1,290
Dibenz(a,h)anthracene	22	34	11	15	21	5.7	12	--	1,300
Dibenzofuran	<2.7	3.3	<2.8	10	5.6	0.99	1.1	--	--
Fluoranthene	160	330	100	120	32	34	38	--	2,230
Fluorene	<2.7	4.8	<2.8	7.6	0.68	0.93	0.91	--	536
Indeno(1,2,3-cd)pyrene	290	430	120	77	46	30	56	--	100
1-Methylnaphthalene	--	--	--	--	--	--	--	--	
2-Methylnaphthalene	4	5.4	3.5	6.4	23	2.1	2.7	--	200
Naphthalene	7.9	9.7	6.3	9.2	23	5.6	8.2	--	561
Phenanthrene	37	92	31	87	20	15	16	--	1,170
Pyrene	220	430	130	120	46	38	52	--	1,520
cPAHs (BaP Eq)	254	450	132	108	77	43	69	106	--
Total PAHs	1,924	3,189	955	880	456	290	432	23,000	--
Total LPAHs	104	205	66	140	79	30	38	1,600	--
Total HPAHs	1,820	2,984	889	740	377	260	394	150,000	--

Notes:

1. Polycyclic Aromatic Hydrocarbons (PAHs) by U.S. Environmental Protection Agency (EPA) Method 8270-SIM. cPAHs - carcinogenic PAHs; LPAHs - low molecular weight PAHs, HPAHs - high molecular weight PAHs
2. µg/kg = micrograms per kilogram (parts per billion).
3. Portland Harbor PRG = Preliminary Remediation Goal proposed by EPA April 11, 2014 (cPAHs - Human Health direct contact; others Ecological toxicity).
4. JSCS SLV = Portland Harbor Joint Source Control Strategy Table 3-1: Screening Level Values for Soil/Storm Water Sediment (7/16/07 Revision).
5. -- = Not analyzed or not available.
6. < = Not detected above the Method Reporting Limit (MRL).
7. Box indicates that the reported concentration exceeds the Portland Harbor PRG.
8. Shading indicates that the reported concentration exceeds the JSCS SLV.
9. Total HPAHs PRG is mg/(kg-%fines)

Table 6 - Riverbank Soil Analytical Results: ISM Polycyclic Aromatic Hydrocarbons (µg/kg)
SIUF - OU2
Portland, Oregon

Sample ID: / Sample Date:	OU5-ISM- <2mm post grind 8/14/2014	Dupe 8/14/2014	Portland Harbor PRG[9]	JSCS SLV
PAHs (µg/kg)				
Acenaphthene	<10.3	<9.93	--	300
Acenaphthylene	43.0	47.8	--	200
Anthracene	28.4	31.4	--	845
Benz(a)anthracene	126	145	--	1,050
Benzo(a)pyrene	223	242	--	1,450
Benzo(b)fluoranthene	--	--	--	--
Benzo(g,h,i)perylene	317	308	--	300
Benzo(k)fluoranthene	--	--	--	13,000
Benzo(b+k)fluoranthene	397	405	--	--
Chrysene	188	208	--	1,290
Dibenz(a,h)anthracene	28.2	31.7	--	1,300
Dibenzofuran	<10.3	<9.93	--	--
Fluoranthene	312	371	--	2,230
Fluorene	<10.3	<9.93	--	536
Indeno(1,2,3-cd)pyrene	252	250	--	100
1-Methylnaphthalene	<10.3	<9.93	--	
2-Methylnaphthalene	<10.3	<9.93	--	200
Naphthalene	<10.3	<9.93	--	561
Phenanthrene	86.4	98.6	--	1,170
Pyrene	420	505	--	1,520
cPAHs (BaP Eq)	332	357	106	--
Total PAHs	2,421	2,644	23,000	--
Total LPAHs	284	323	1,600	--
Total HPAHs	2,137	2,321	150,000	--

Notes:
1. Polycyclic Aromatic Hydrocarbons (PAHs) by U.S. Environmental Protection Agency (EPA) Method 8270-SIM. cPAHs - carcinogenic PAHs; LPAHs - low molecular weight PAHs, HPAHs - high molecular weight PAHs
2. µg/kg = micrograms per kilogram (parts per billion).
3. Portland Harbor PRG = Preliminary Remediation Goal proposed by EPA April 11, 2014 (cPAHs - Human Health direct contact; others Ecological toxicity).
4. JSCS SLV = Portland Harbor Joint Source Control Strategy Table 3-1: Screening Level Values for Soil/Storm Water Sediment (7/16/07 Revision).
5. -- = Not analyzed or not available.
6. < = Not detected above the Method Reporting Limit (MRL).
7. Box indicates that the reported concentration exceeds the Portland Harbor PRG.
8. Shading indicates that the reported concentration exceeds the JSCS SLV.
9. Total HPAHs PRG is mg/(kg-%fines)

Table 7 - Riverbank Soil Analytical Results: Discrete Polychlorinated Biphenyls (µg/kg)
SIUF - OU2
Portland, Oregon

Sample ID:	RB-8a	RB-8b	RB-9a	RB-9b	RB-10a	RB-10b	RB-11a	RB-11b	RB-12a	RB-12b	RB-13a	RB-13b	RB-14a	RB-14b	RB-15a	RB-15b	OU5-SS-02	OU5-SS-04	OU5-SS-06	Portland Harbor PRG	JSCS SLV
Sample Date:	10/6/2011	10/6/2011	10/6/2011	10/6/2011	10/6/2011	10/6/2011	10/6/2011	10/6/2011	10/6/2011	10/6/2011	10/6/2011	10/6/2011	10/6/2011	10/6/2011	10/6/2011	10/6/2011	8/14/2014	8/14/2014	8/14/2014	PRG	SLV
PCBs (µg/kg)																					
Aroclor 1016	<5.0	<5.1	<5.1	<5.2	<5.1	<4.9	<5.2	<5.0	<5.6	<5.0	<5.1	<5.1	<5.7	<5.4	<7.3	<7.2	<4.18	<4.14	<4.11	--	530
Aroclor 1221	<2.5	<2.6	<2.5	<2.6	<2.6	<2.4	<2.6	<2.5	<2.8	<2.5	<2.6	<2.5	<2.8	<2.7	<3.6	<3.6	<4.18	<4.14	<4.11	--	--
Aroclor 1232	<3.5	<3.6	<3.5	<3.6	<3.6	<3.4	<3.6	<3.5	<3.9	<3.5	<3.6	<3.5	<4.0	<3.8	<5.1	<5.0	<4.18	<4.14	<4.11	--	--
Aroclor 1242	<4.6	<4.7	<4.7	<4.8	<4.7	<4.5	<4.8	<4.6	<5.2	<4.7	<4.7	<4.7	<5.2	<5.0	<6.7	<6.6	<4.18	<4.14	<4.11	--	--
Aroclor 1248	<4.4	<4.5	<4.5	<4.5	<4.5	<4.3	<4.6	<4.4	<4.9	<4.4	<4.5	<4.5	<5.0	<4.8	<6.4	<6.3	<4.18	<4.14	<4.11	--	1,500
Aroclor 1254	<2.7	<2.7	<2.7	<2.8	<2.7	<2.6	<2.8	<2.7	<3.0	<2.7	<2.7	<2.7	<3.0	<2.9	<3.9	<3.8	<4.18	<4.14	<4.11	--	300
Aroclor 1260	26.4	12.6 J	154	156	77.3	613	<5.5	58.0	10.3 J	25.7	<5.5	7.8 J	9.8 J	71.1	<7.8	<7.7	78.2	46.4	124	--	200
Aroclor 1262	<3.1	<3.2	<3.2	<3.2	<3.2	<3.1	<3.2	<3.1	<3.5	<3.2	<3.2	<3.2	<3.6	<3.4	<4.6	<4.5	<4.18	<4.14	<4.11	--	--
Aroclor 1268	<1.4	<1.5	<1.5	<1.5	<1.5	<1.4	<1.5	<1.4	<1.6	<1.5	<1.5	<1.5	<1.6	<1.6	<2.1	<2.1	<4.18	<4.14	<4.11	--	--
Total PCBs	26.4	12.6 J	154	156	77.3	613	<5.5	58	10.3 J	25.7	<5.5	7.8 J	9.8 J	71.1	<7.8	<7.7	78.2	46.4	124	6	0.39

Notes:

1. Polychlorinated Biphenyl (PCB) Aroclors by U.S. Environmental Protection Agency (EPA) Method 8082.
2. µg/kg = micrograms per kilogram (parts per billion).
3. Portland Harbor PRG = Preliminary Remediation Goal proposed by EPA April 11, 2014 (RAO 2 - Human Health bioaccumulation).
4. JSCS SLV = Portland Harbor Joint Source Control Strategy Table 3-1: Screening Level Values for Soil/Storm Water Sediment (7/16/07 Revision).
5. -- = Not analyzed or not available.
6. < = Not detected above the Method Reporting Limit (MRL).
7. Box indicates that the reported concentration exceeds the Portland Harbor PRG.
8. Shading indicates that the reported concentration exceeds the JSCS SLV.
9. Total PCBs = Sum of the detected Aroclors or the highest detection limit when not detected.
10. J = Estimated.

Table 8 - Riverbank Soil Analytical Results: Composite Polychlorinated Biphenyls (µg/kg)
SIUF - OU2
Portland, Oregon

Outfall Pipe ID:	WR-164	WR-159	WR-160	WR-399	CG-26	CG-27	WR-159a				
Sample ID:	RB-1 Composite	RB-2 Composite	RB-3 Composite	RB-4 Composite	RB-5 Composite	RB-6 Composite	RB-7 Composite	Sub A - 2011 (Comp A)	Sub A - 2011 - (Comp B)	Portland Harbor PRG	JSCS SLV
Sample Date:	9/26/2006	9/26/2006	9/26/2006	10/1/2008	10/1/2008	10/1/2008	10/1/2008	2/16/2011	2/16/2011		
PCBs (µg/kg)											
Aroclor 1016	<54	<52	<55	<10	<10	<10	<10	<5.5	<5.8	--	530
Aroclor 1221	<110	<110	<110	<20	<20 i	<20 i	<20	<2.8	<2.9	--	--
Aroclor 1232	<54	<52	<55	<10	<10 i	<10 i	<10	<3.8	<4.0	--	--
Aroclor 1242	<54	<52	<55	<10	<10 i	<10	<10	<5.1	<5.3	--	--
Aroclor 1248	<54	<52	<55	<10	<10 i	<10 i	<10	<4.9	<5.1	--	1,500
Aroclor 1254	<54	<52	<55	23	<10	<10	14 P	<2.9	<3.1	--	300
Aroclor 1260	72	77	<55	68	53	78	44	24.8	<6.2	--	200
Aroclor 1262	--	--	--	<10	<10	<10	<10	<3.5	<3.6	--	--
Aroclor 1268	--	--	--	<10	<10	<10	<10	<1.6	<1.7	--	--
Total PCBs	72	77	<110	91	53	78	58	24.8	<6.2	6	0.39

Notes:

1. Polychlorinated Biphenyl (PCB) Aroclors by U.S. Environmental Protection Agency (EPA) Method 8082.
2. µg/kg = micrograms per kilogram (parts per billion).
3. Portland Harbor PRG = Preliminary Remediation Goal proposed by EPA April 11, 2014 (RAO 2 - Human Health bioaccumulation).
4. JSCS SLV = Portland Harbor Joint Source Control Strategy Table 3-1: Screening Level Values for Soil/Storm Water Sediment (7/16/07 Revision).
5. -- = Not analyzed or not available.
6. < = Not detected above the Method Reporting Limit (MRL).
7. Box indicates that the reported concentration exceeds the Portland Harbor PRG.
8. Shading indicates that the reported concentration exceeds the JSCS SLV.
9. Total PCBs = Sum of the detected Aroclors or the highest detection limit when not detected.
10. i = The MRL/Method Detection Limit (MDL) has been elevated due to chromatic interference.
11. P = The GC or HPLC confirmation criteria was exceeded. The relative percent difference is greater

than 40 percent between the two analytical results.

Table 9 - Riverbank Soil Analytical Results: ISM Polychlorinated Biphenyls (µg/kg)
SIUF - OU2
Portland, Oregon

Sample ID: Sample Date:	OU5-ISM- <2mm post grind 8/14/2014	Dupe 8/14/2014	Portland Harbor PRG	JSCS SLV
PCBs (µg/kg)				
Aroclor 1016	<10.2	<10.1	--	--
Aroclor 1221	<10.2	<10.1	--	--
Aroclor 1232	<10.2	<10.1	--	--
Aroclor 1242	<10.2	<10.1	--	--
Aroclor 1248	<10.2	<10.1	--	1,500
Aroclor 1254	28.3 J1	40.5 J1	--	300
Aroclor 1260	55.1 J1	63.5 J1	--	200
Aroclor 1262	<10.2	<10.1	--	--
Aroclor 1268	<10.2	<10.1	--	--
Total PCBs	83.4	104	6	0.39

Notes:

1. Polychlorinated Biphenyl (PCB) Aroclors by U.S. Environmental Protection Agency (EPA) Method 8082.
2. µg/kg = micrograms per kilogram (parts per billion).
3. Portland Harbor PRG = Preliminary Remediation Goal proposed by EPA April 11, 2014 (RAO 2 - Human Health bioaccumulation).
4. JSCS SLV = Portland Harbor Joint Source Control Strategy Table 3-1: Screening Level Values for Soil/Storm Water Sediment (7/16/07 Revision).
5. -- = Not analyzed or not available.
6. < = Not detected above the Method Reporting Limit (MRL).
7. Box indicates that the reported concentration exceeds the Portland Harbor PRG.
8. Shading indicates that the reported concentration exceeds the JSCS SLV.
9. Total PCBs = Sum of the detected Aroclors or the highest detection limit when not detected.
10. J1 = Result estimated due to the presence of multiple PCB Aroclors and/or matrix interference.

Table 10 - Riverbank Soil Analytical Results: Discrete Butyl Tins (ug/kg)
SIUF - OU2
Portland, Oregon

Outfall Pipe ID:	WR-399			CG-26			CG-27				
Sample ID:	RB-4a	RB-4b	RB-4c	RB-5a	RB-5b	RB-5c	RB-6a	RB-6b	RB-6c	Portland Harbor PRG	JSCS SLV
Sample Date:	10/1/2008	10/1/2008	10/1/2008	10/1/2008	10/1/2008	10/1/2008	10/1/2008	10/1/2008	10/1/2008		
Tri-n-butyltin (µg/kg)											
TBT	67	580 D	< 5.0	32	<4.9	< 5.0	380 D	7.0	<4.9	4,000	2.3

Sample ID:	RB-8a	RB-8b	RB-10a	RB-10b	RB-11a	RB-11b	RB-13a	RB-13b	Portland Harbor PRG	JSCS SLV
Sample Date:	10/6/2011	10/6/2011	10/6/2011	10/6/2011	10/6/2011	10/6/2011	10/6/2011	10/6/2011		
Butyl Tins										
TBT	240	3.0 J	3.0 J	2.5 J	130	<3.2	<3.4	<3.4	4,000	2.3
Dibutyltin Ion	46	<4.9	3.8 J	11	7.3	<4.9	<5.0	<5.0	--	--
Butyltin Ion	15	2.7 J	3.4 J	6.8	12	<3.4	<3.5	1.8 J	--	--
Tetrabutyltin Ion	<4.3	<4.2	<4.3	<4.1	<4.4	<4.2	<4.3	<4.3	--	--

Notes:

1. Butyl tins by Krone Method.
2. µg/kg = micrograms per kilogram (parts per billion).
3. Portland Harbor PRG = Preliminary Remediation Goal proposed by EPA April 11, 2014 (RAO 2 - Human Health bioaccumulation).
4. JSCS SLV = Portland Harbor Joint Source Control Strategy Table 3-1: Screening Level Values for Soil/Storm Water Sediment (7/16/07 Revision).
5. -- = Not analyzed or not available.
6. < = Not detected above the Method Reporting Limit (MRL).
7. Box indicates that the reported concentration exceeds the Portland Harbor PRG.
8. Shading indicates that the reported concentration exceeds the JSCS SLV.
9. D = The reported result is from a dilution.
10. J = Estimated.

Table 11 - Riverbank Soil Analytical Results: Composite Butyl Tins (ug/kg)
SIUF - OU2
Portland, Oregon

Outfall Pipe ID:	WR-399	CG-26	CG-27		
Sample ID:	RB-4 Composite	RB-5 Composite	RB-6 Composite	Portland Harbor PRG	JSCS SLV
Sample Date:	10/1/2008	10/1/2008	10/1/2008		
Tri-n-butyltin (µg/kg)					
TBT	130 D	17	120	4,000	2.3

Notes:

1. Butyl tins by Krone Method.
2. µg/kg = micrograms per kilogram (parts per billion).
3. Portland Harbor PRG = Preliminary Remediation Goal proposed by EPA April 11, 2014 (RAO 2 - Human Health bioaccumulation).
4. JSCS SLV = Portland Harbor Joint Source Control Strategy Table 3-1: Screening Level Values for Soil/Storm Water Sediment (7/16/07 Revision).
5. -- = Not analyzed or not available.
6. < = Not detected above the Method Reporting Limit (MRL).
7. Box indicates that the reported concentration exceeds the Portland Harbor PRG.
8. Shading indicates that the reported concentration exceeds the JSCS SLV.
9. D = The reported result is from a dilution.

Table 12 - Preliminary Remediation Goals and Remedial Action Objectives
SIUF - OU2
Portland, Oregon

RAO No.	Receptor Group	Exposure Scenario	PRGs			
			PCBs	cPAHs	Copper	Lead
			(ug/kg)		(mg/kg)	
1	Human Health	Direct Contact	370	106	--	--
2	Human Health	Bioaccumulation	6	4,000	--	--
5	Ecological	Toxicity	126	--	165	96
6	Ecological	Bioaccumulation	40	--	--	--

Notes:
1. PCBs = Polychlorinated biphenyls.
2. cPAHs = Carcinogenic polynuclear aromatic hydrocarbons.
3. µg/kg = micrograms per kilogram (parts per billion).
4. mg/kg = milligrams per kilogram.
5. RAO = Remedial Action Objectives.
6. PRG = Preliminary Remediation Goal.
7. -- = PRG is not available.

Table 13 - Area-Weighted Average Concentrations - cPAHs
SIUF - OU2
Portland, Oregon

Discrete Samples

Sample ID	cPAHs (BaP Eq) µg/kg	Areas (sf)	Conc. x Area (sf-µg/kg)
RB-1a	206	600	123600
RB-1b	271	600	162600
RB-1c	224	600	134400
RB-2a	179	970	173630
RB-2b	749	970	726530
RB-2c	332	970	322040
RB-3a	117	6310	738270
RB-3b	98	6310	618380
RB-3c	262	6310	1653220
RB-8a	420	16480	6921600
RB-9b	222	4310	956820
RB-10b	1,331	3150	4192650
RB-11b	96	5720	549120
RB-12b	64	4170	266880
RB-13b	16	9420	150720
RB-14b	117	7970	932490
RB-15b	154	39800	6129200
OU5-SS-02	455	3780	1719900
OU5-SS-04	86	2610	224460
OU5-SS-06	66	2170	143220
	Totals	123220	26839730

Area-Weighted Average Concentration	218
RAO 1 PRG	106
RAO 2 PRG	4000

Composite Samples

Sample ID	cPAHs (BaP Eq) µg/kg	Areas (sf)	Conc. x Area (sf-µg/kg)
RB-1 Composite	254	35100	8915400
RB-2 Composite	450	11200	5040000
RB-3 Composite	132	15900	2098800
RB-4 Composite	108	25400	2743200
RB-5 Composite	77	12000	924000
RB-6 Composite	43	13600	584800
RB-7 Composite	69	10800	745200
	Totals	124000	21051400

Area-Weighted Average Concentration	170
RAO 1 PRG	106
RAO 2 PRG	4000

ISM Sample

Sample ID	cPAHs (BaP Eq) µg/kg
OU5-ISM (Duplicate)	357

Area-Weighted Average Concentration	357
RAO 1 PRG	106
RAO 2 PRG	4000

Notes:
1. cPAHs = Carcinogenic polynuclear aromatic hydrocarbons.
2. BaP Eq = benzo(a)pyrene equivalent.
3. sf = square feet.
4. µg/kg = micrograms per kilogram (parts per billion).

Table 14 - Area-Weighted Average Concentrations - Total PCBs
SIUF - OU2
Portland, Oregon

Discrete Samples

Sample ID	Total PCBs µg/kg	Areas (sf)	Conc. x Area (sf-µg/kg)
RB-8a	26.4	16480	435072
RB-9b	156	4310	672360
RB-10b	613	4020	2464260
RB-11b	58	5720	331760
RB-12b	25.7	6340	162938
RB-13b	7.8	10100	78780
RB-14b	71.1	26100	1855710
RB-15a	3.9	41100	160290
OU5-SS-02	78.2	3780	295596
OU5-SS-04	46.4	2610	121104
OU5-SS-06	124	3400	421600
	Totals	123960	6999470

Area-Weighted Average Concentration	56
RAO 1 PRG	370
RAO 2 PRG	6
RAO 6 PRG	40

Composite Samples

Sample ID	Total PCBs µg/kg	Areas (sf)	Conc. x Area (sf-µg/kg)
RB-1 Composite	72	35100	2527200
RB-2 Composite	77	11200	862400
RB-3 Composite	55	15900	874500
RB-4 Composite	91	25400	2311400
RB-5 Composite	53	8510	451030
RB-6 Composite	78	9820	765960
RB-7 Composite	58	10800	626400
Sub A - 2011 (Comp A)	24.8	3640	90272
Sub A - 2011 - (Comp B)	3.1	3640	11284
	Totals	124010	8520446

Area-Weighted Average Concentration	69
RAO 1 PRG	370
RAO 2 PRG	6
RAO 6 PRG	40

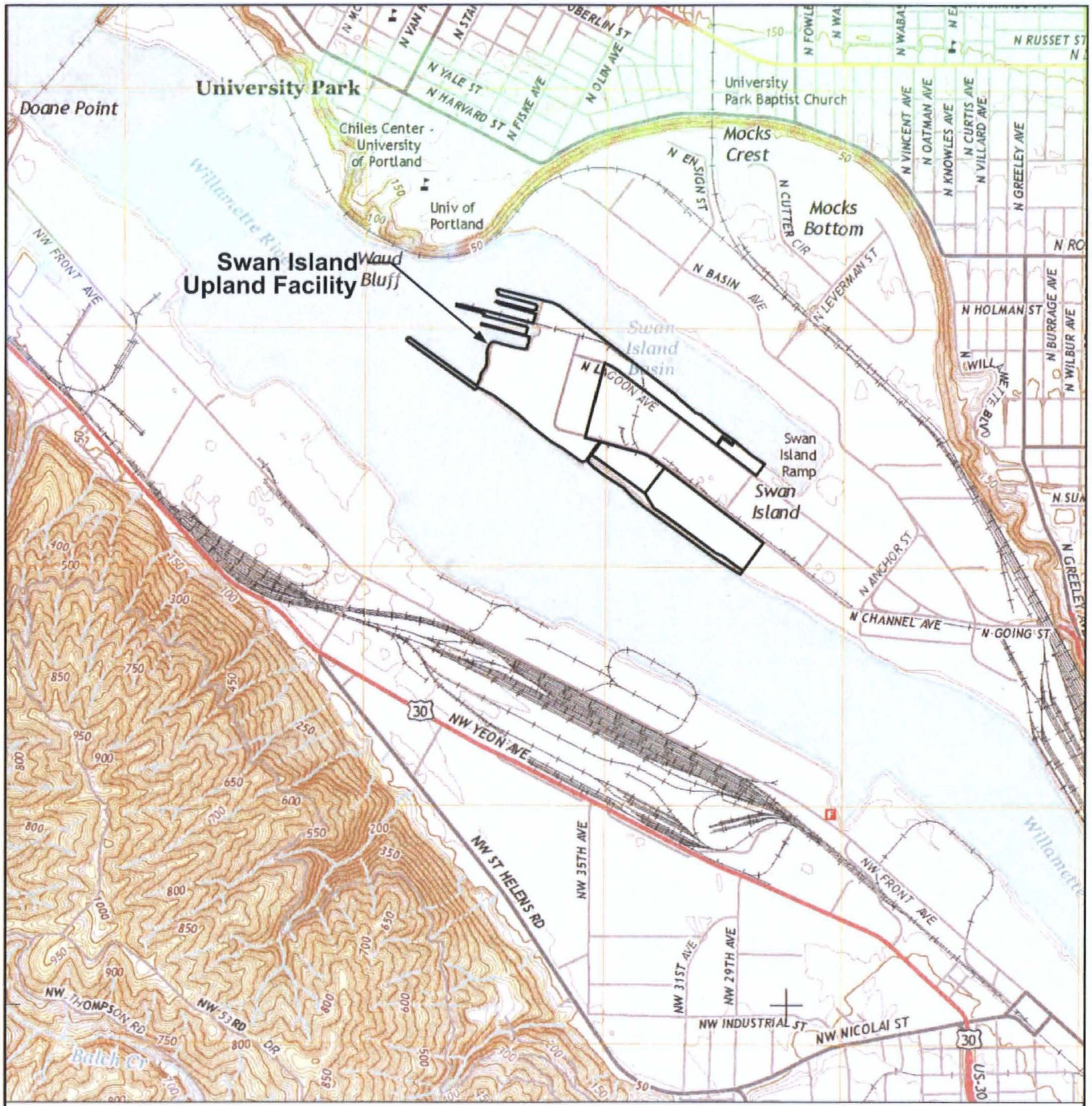
ISM Sample

Sample ID	Total PCBs µg/kg
OU5-ISM (Duplicate)	104

Area-Weighted Average Concentration	104
RAO 1 PRG	370
RAO 2 PRG	6
RAO 6 PRG	40

Notes:
1. PCBs = Polychlorinated biphenyls.
2. sf = square feet.
3. µg/kg = micrograms per kilogram (parts per billion).

Figures



Note: Base map prepared from USGS 7.5-minute quadrangle of Portland, OR, dated 2014 as provided by USGS.gov.

0 2,000 4,000

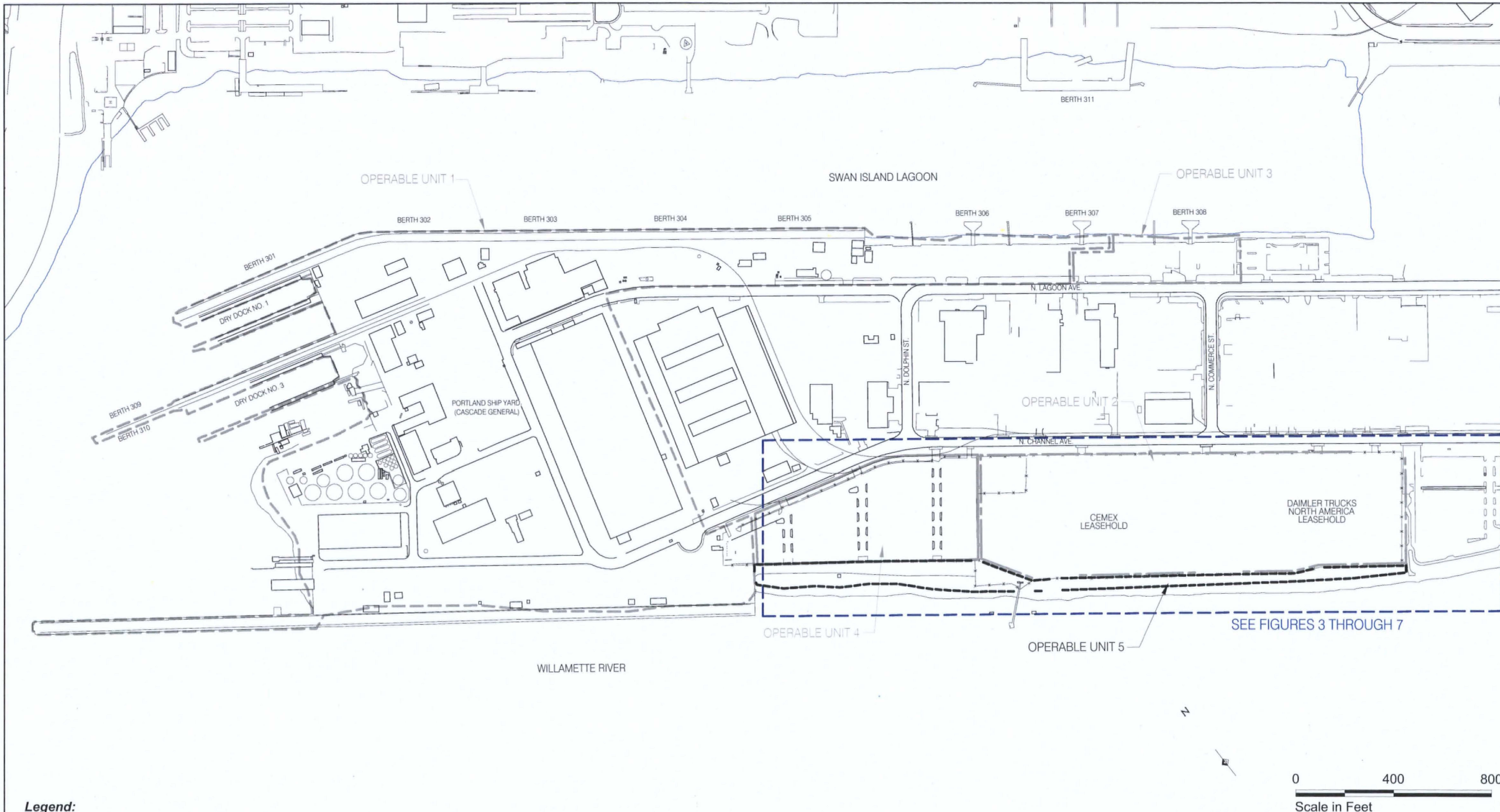
Approximate Scale in Feet

N

Facility Location Map

Source Control Alternative Evaluation
Swan Island Upland Facility Operable Unit 5
Portland, Oregon

APEX Apex Companies, LLC 3015 SW First Avenue Portland, Oregon 97201	Project Number	1115-17	Figure
	January 2015		1



Legend:

- Operable Unit 1 Boundary
- Operable Unit 2 Boundary
- Operable Unit 3 Boundary
- Operable Unit 4 Boundary
- Operable Unit 5 Boundary

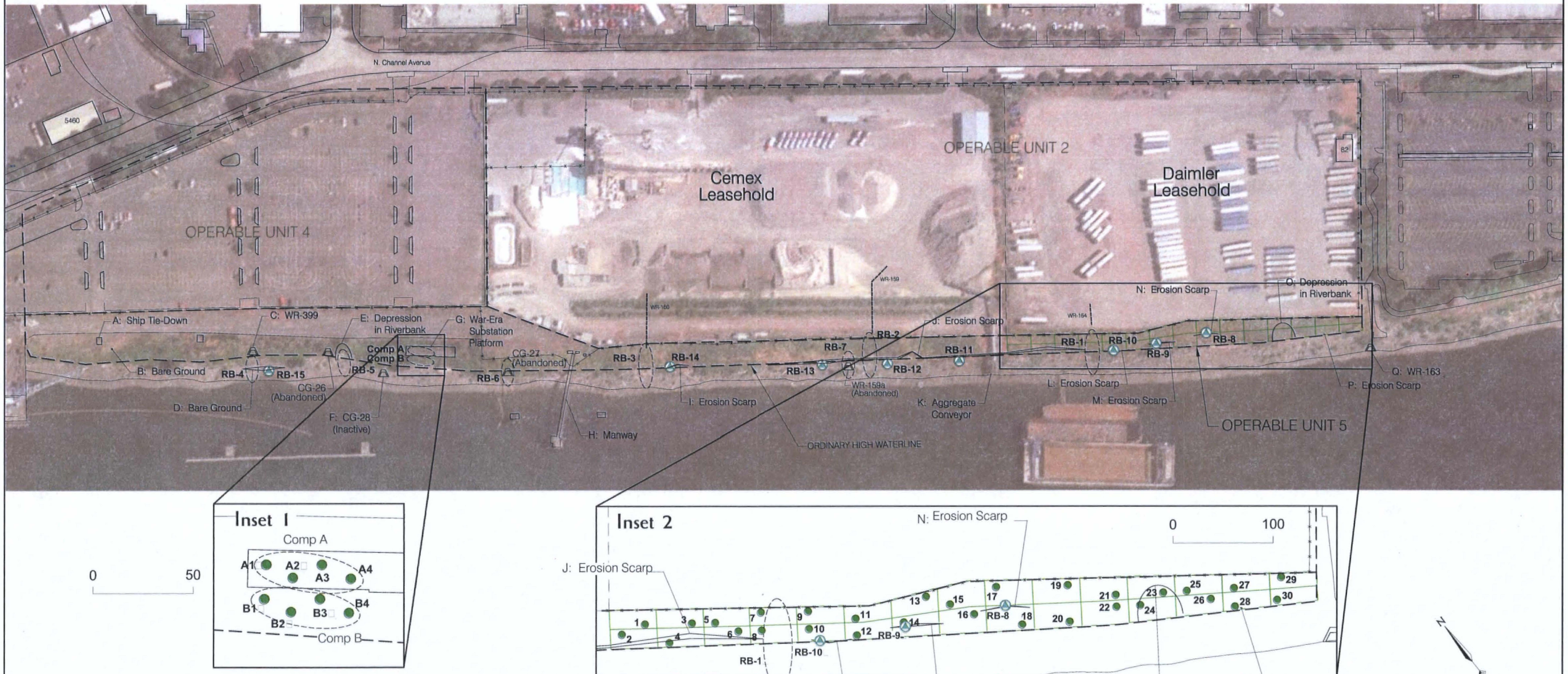
NOTE:
1. Prepared from AutoCAD base map received from the Port of Portland in June 2007.

Facility Vicinity Plan

Source Control Alternative Evaluation
Swan Island Upland Facility Operable Unit 5
Portland, Oregon

APEX
Apex Companies, LLC
3015 SW First Avenue
Portland, Oregon 97201

Project Number	1115-17	Figure
January 2015		2



Legend:

1 ●	Incremental/Discrete Sample Location
WR-399	Outfall Location and Designation
WR-160	Storm Water Pipe Location and Designation (Abandoned July 2006)
RB-8	Riverbank Soil Sampling Location (RB-8 through RB-15)
RB-4	Historical Composite Riverbank Sample Location (RB-1 through RB-7)
	Proposed Source Control Measure Area

NOTES:

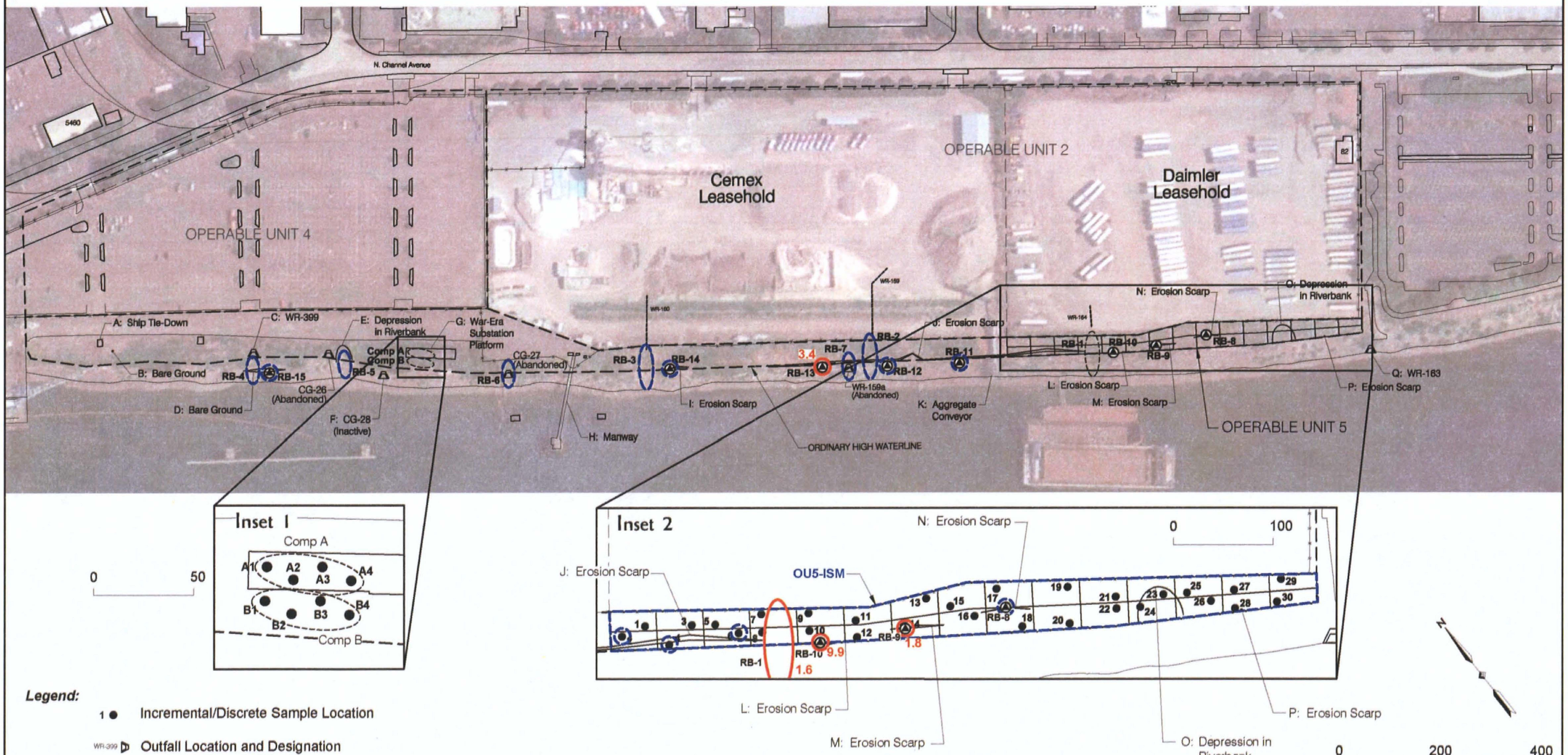
1. Prepared from AutoCAD base map received from the Port of Portland in June 2007.
2. Aerial photograph from Google Imagery dated August 20, 2011.

OU5 Facility Plan

Source Control Alternative Evaluation
Swan Island Upland Facility Operable Unit 5
Portland, Oregon

APEX
Apex Companies, LLC
3015 SW First Avenue
Portland, Oregon 97201

Project Number	1115-17	Figure
January 2015		3



Legend:

- 1 ● Incremental/Discrete Sample Location
- WR-399 Outfall Location and Designation
- WR-160 Storm Water Pipe Location and Designation (Abandoned July 2006)
- RB-8 Riverbank Soil Sampling Location (RB-8 through RB-15)
- RB-4 Historical Composite Riverbank Sample Location (RB-1 through RB-7)
- Proposed Source Control Measure Area
- <PRG for RAO 5
- >Preliminary Remediation Goal (PRG) for RAO 5
- 3.4 Exceedance Ratio

NOTES:

1. Prepared from AutoCAD base map received from the Port of Portland in June 2007.
2. Aerial photograph from Google Imagery dated August 20, 2011.

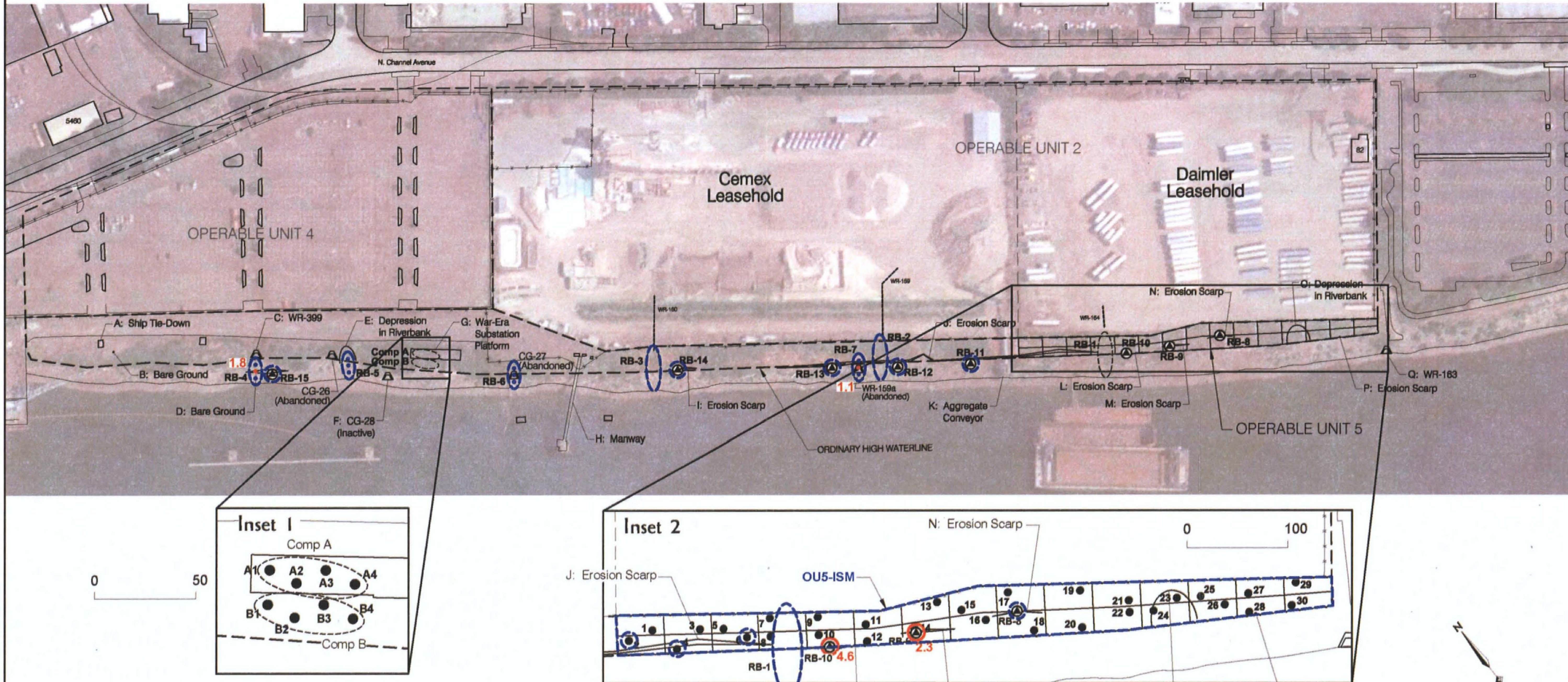
PRGs for RAO 5 - Copper

Source Control Alternative Evaluation
Swan Island Upland Facility Operable Unit 5
Portland, Oregon

APEX

Apex Companies, LLC
3015 SW First Avenue
Portland, Oregon 97201

Project Number	1115-17	Figure
January 2015		4



Legend:

- 1 ● Incremental/Discrete Sample Location
- WR-399 Outfall Location and Designation
- WR-160 Storm Water Pipe Location and Designation (Abandoned July 2006)
- RB-8 Riverbank Soil Sampling Location (RB-8 through RB-15)
- RB-4 Historical Composite Riverbank Sample Location (RB-1 through RB-7)
- Proposed Source Control Measure Area
- <PRG for RAO 5
- >Preliminary Remediation Goal (PRG) for RAO 5
- 4.6 Exceedance Ratio

NOTES:

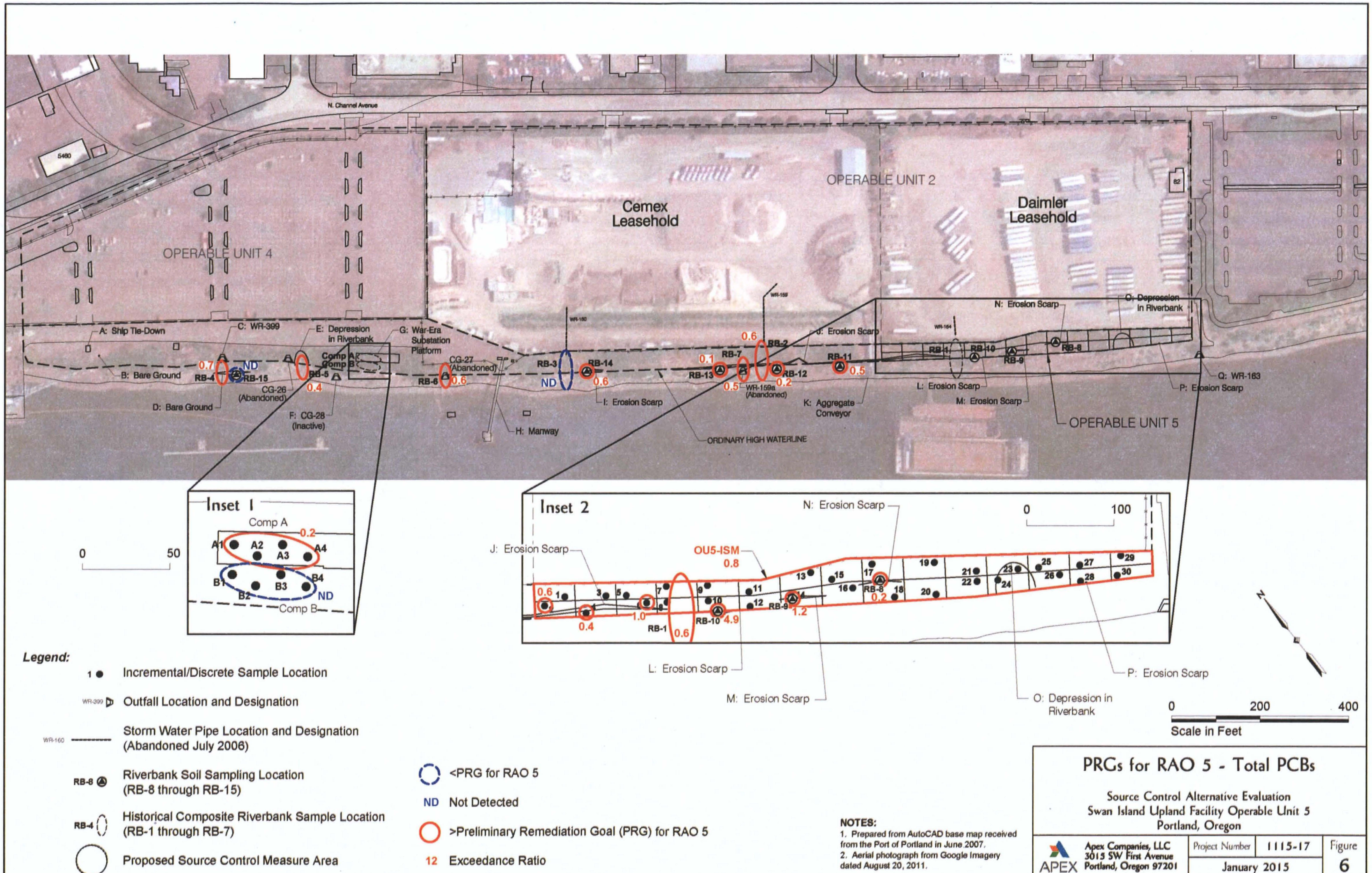
1. Prepared from AutoCAD base map received from the Port of Portland in June 2007.
2. Aerial photograph from Google Imagery dated August 20, 2011.

PRGs for RAO 5 - Lead

Source Control Alternative Evaluation
Swan Island Upland Facility Operable Unit 5
Portland, Oregon

APEX
Apex Companies, LLC
3015 SW First Avenue
Portland, Oregon 97201

Project Number	1115-17	Figure
January 2015		5



N. Channel Avenue
5460
OPERABLE UNIT 4
OPERABLE UNIT 2
Cemex Leasehold
Daimler Leasehold
OPERABLE UNIT 5
A: Ship Tie-Down
B: Bare Ground
C: WR-399
D: Bare Ground
E: Depression in Riverbank
F: CG-28 (Inactive)
G: War-Era Substation Platform
H: Manway
I: Erosion Scarp
J: Erosion Scarp
K: Aggregate Conveyor
L: Erosion Scarp
M: Erosion Scarp
N: Erosion Scarp
O: Depression in Riverbank
P: Erosion Scarp
Q: WR-163
CG-26 (Abandoned)
CG-27 (Abandoned)
WR-159a (Abandoned)
ORDINARY HIGH WATERLINE
Comp A
Comp B
RB-1 RB-2 RB-3 RB-4 RB-5 RB-6 RB-7 RB-8 RB-9 RB-10 RB-11 RB-12 RB-13 RB-14 RB-15
0.7 ND 0.4 0.6 ND 0.6 0.1 0.5 0.6 0.2 0.5
Inset 1
Comp A
0.2
A1 A2 A3 A4
B1 B2 B3 B4
ND
Comp B
0 50
Inset 2
0 100
J: Erosion Scarp
N: Erosion Scarp
OU5-ISM 0.8
0.6 0.4 1.0 0.6 4.9 1.2 0.2
L: Erosion Scarp
M: Erosion Scarp
O: Depression in Riverbank
P: Erosion Scarp
0 200 400
Scale in Feet
Legend:
Incremental/Discrete Sample Location
Outfall Location and Designation
Storm Water Pipe Location and Designation (Abandoned July 2006)
Riverbank Soil Sampling Location (RB-8 through RB-15)
Historical Composite Riverbank Sample Location (RB-1 through RB-7)
Proposed Source Control Measure Area
<PRG for RAO 5
ND Not Detected
>Preliminary Remediation Goal (PRG) for RAO 5
12 Exceedance Ratio
NOTES:
1. Prepared from AutoCAD base map received from the Port of Portland in June 2007.
2. Aerial photograph from Google Imagery dated August 20, 2011.
PRGs for RAO 5 - Total PCBs
Source Control Alternative Evaluation
Swan Island Upland Facility Operable Unit 5
Portland, Oregon
APEX
Apex Companies, LLC
3015 SW First Avenue
Portland, Oregon 97201
Project Number 1115-17
January 2015
Figure 6

EROSION SCARPS TARGETED FOR SOURCE CONTROL MEASURE

0 200 400
Scale in Feet

Legend:

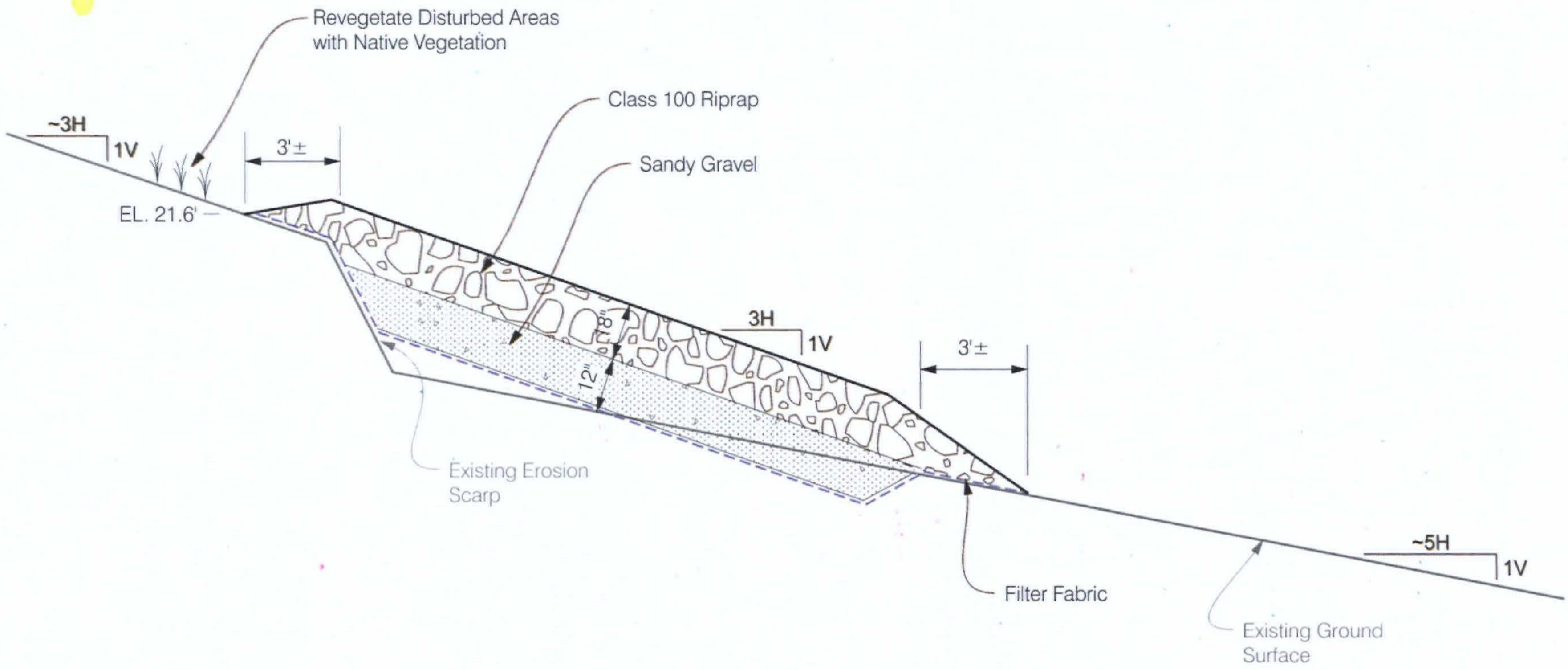
- WR-399 — Outfall Location and Designation
- WR-160 — Storm Water Pipe Location and Designation (Abandoned July 2006)
- RB-8 — Riverbank Soil Sampling Location (RB-8 through RB-15)
- RB-4 — Historical Composite Riverbank Sample Location (RB-1 through RB-7)

NOTES:
1. Prepared from AutoCAD base map received from the Port of Portland in June 2007.
2. Aerial photograph from Google Imagery dated August 20, 2011.

Source Control Measure Areas

Source Control Alternative Evaluation
Swan Island Upland Facility Operable Unit 5
Portland, Oregon

APEX Apex Companies, LLC 3015 SW First Avenue Portland, Oregon 97201	Project Number	1115-17	Figure 7
	January 2015		



NOTES:

1) Not to Scale
2) Balance Cut/Fill for Subgrade Preparation
3) Elevations NGVD47

Proposed Source Control Schematic

Source Control Alternative Evaluation
Swan Island Upland Facility Operable Unit 5
Portland, Oregon

APEX — Apex Companies, LLC 3015 SW First Avenue Portland, Oregon 97201	Project Number	1115-17	Figure
	January 2015		8

Appendix A

Appendix A

River Stage Data Evaluation

Appendix A – River Stage Data Evaluation

This appendix describes the development of the river stage frequency distribution. Table A-1 presents the river stage frequency data and Figure A-1 is a histogram showing the relative frequency of river stage.

Willamette river stage elevation data were obtained for the period of October 1, 1988 through December 16, 2014 from the USGS water science data center (http://or.water.usgs.gov/). The data were obtained for the USGS gauge 14211720 located in Portland, Oregon. In general, the data set consists of river elevation data measurements that were collected twice an hour for the duration of the study period. Approximately 5% of the potential data set (23,000 out of 460,000 data points) was not available due to gauge maintenance, repairs, and/or technical difficulties. For the purpose of the analysis, it was assumed that the missing data were randomly distributed. The data are collected in City of Portland Datum and were converted from gauge datum to feet above mean sea level (MSL) in North American Vertical Datum of 1988 by adding 2.18 feet.

Over the monitoring period, river stage ranged from a low of 4.54 feet MSL in September 2003 to a high of 32.84 feet MSL in February 1996. Over the course of the 26-year period, the average river stage was 10.75-feet MSL, and the median river stage was 10.13-feet MSL. The data shows a right-skewed normal distribution. The lowest river stages generally occur between July and early November, with the highest river stages generally occurring January through June. Except for a brief period in January 1997, all river stages above 28 feet (constituting about 0.1% of the total) occurred in February 1996 during the Willamette Valley Flood of 1996.

Table A-1 - Willamette River Stage Frequency, 1989 - 2015 (NAVD88)
SIUF - OU2
Portland, Oregon

River Stage (feet above MSL)	Frequency	Percent of time at the given river stage	Cumulative
5	88	0.02%	0.02%
6	5074	1.2%	1.18%
7	22436	5.1%	6.33%
8	48884	11%	17.54%
9	65278	15%	32.52%
10	67865	16%	48.08%
11	59461	14%	61.72%
12	46740	11%	72.44%
13	34306	7.9%	80.31%
14	25260	5.8%	86.11%
15	18840	4.3%	90.43%
16	13493	3.1%	93.52%
17	8088	1.9%	95.38%
18	5436	1.2%	96.62%
19	4786	1.1%	97.72%
20	3082	0.7%	98.43%
21	2217	0.5%	98.94%
22	2300	0.5%	99.47%
23	1231	0.3%	99.75%
24	557	0.1%	99.88%
25	90	0.02%	99.90%
26	60	0.01%	99.91%
27	77	0.02%	99.93%
28	115	0.03%	99.95%
29	29	0.01%	99.96%
30	25	0.01%	99.97%
31	35	0.01%	99.97%
32	45	0.01%	99.98%
33	66	0.02%	100.00%
Totals	435,964	100.00%	100.00%

Notes:

1. River stage in feel above mean sea level (MSL), NAVD88 datum.
2. Each point represents one river stage measurment collected in a 12-hour period.
3. Bold and underlined river stage is the approximate ordinatry high water mark (OHWM assuming the OHWM equals the water elevation that was exceeded less than 2% of the time over the 25 year data set.

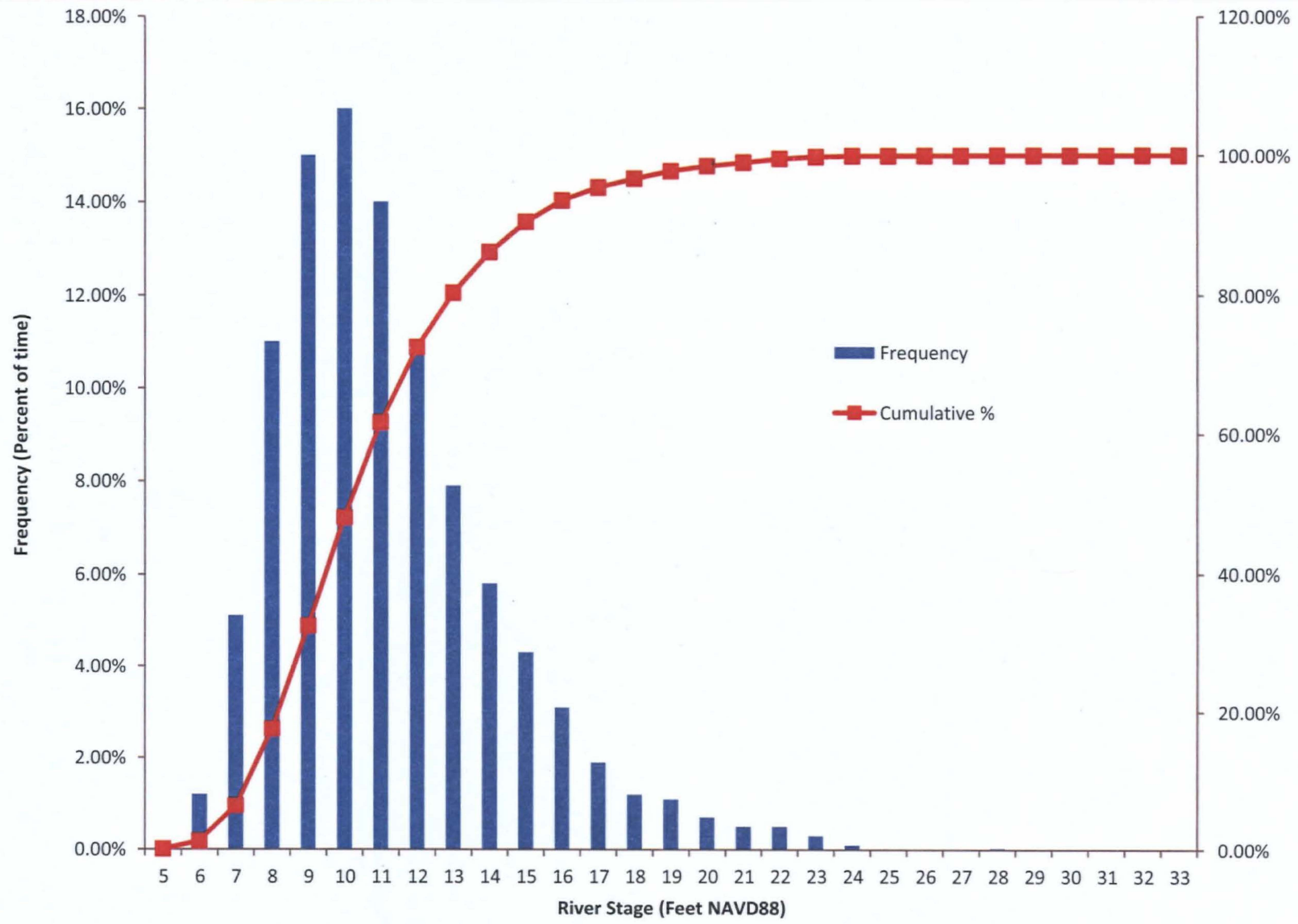

18.00%
16.00%
14.00%
12.00%
10.00%
8.00%
6.00%
4.00%
2.00%
0.00%
Frequency (Percent of time)
120.00%
100.00%
80.00%
60.00%
40.00%
20.00%
0.00%
Frequency
Cumulative %
5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33
River Stage (Feet NAVD88)

Figure A-1